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## CONTENTS

# FLORAL BIOLOGY AND FRUIT-DROP IN SOME MANGO VARIETIES OF PUNJAB

J. S. JAWANDA and K. KIRPAL SINGH

*Fruit Section, Punjab, Patiala*

Received: October 25, 1960

MANGO occupies a premier place in the fruit-growing industry of the Punjab. Its immense popularity can be judged from the fact that out of the total estimated area of 60,000 acres under fruits in this State, not less than 70 per cent is found under mango alone. Barring the hilly tracts with elevations of more than 3,000 feet and very hot and arid zones of the south-west Punjab, mango is extensively grown throughout the State. It is, however, most successful in the submontane tracts.

The greatest problem facing the mango industry is that almost all the commercial varieties are irregular bearers. This problem has so far defied solution, although many research workers have tried to tackle it from different angles. The development of a suitable variety or varieties which may possess a regular bearing habit in addition to other desirable characters is one of the fundamental methods of approach to this complex problem.

In order to achieve the objective, it is essential to carry out an intensive programme of planned breeding. Most of the research workers (Singh and Tomar, 1949; Singh, 1954; Roy, 1957; Sen *et al.*, 1946) have concluded that through breeding alone would it be possible to evolve regular bearing varieties, as other means have failed to yield satisfactory results. For any such programme, precise knowledge on the morphology of the mango flower, sex distribution, rate and time of anthesis, and rate of fruit-drop is an essential prerequisite.

Studies on the flowering and bearing habit of mango were carried out by Naik and Rao (1943) in South India, Musahib-ud-Din and Dhinsa (1946) in the Punjab, and Sen *et al.* (*loc. cit.*) in Bihar. More recently, Singh (1954 a, b) and Mallik (1957) have reported work on the problem from Saharanpur (U.P.) and Sabour (Bihar), respectively. Mukherjee (1951) carried out fruit-set studies in mango. Systematic studies on the floral biology of mango and the subsequent development of the fruit in respect of important varieties grown in the Punjab have not so far been adequately made.

## MATERIAL

Material for these studies was available at the Government Fruit Farm, Qadian, District Gurdaspur. This orchard was planted some 20 years back. It contains about one hundred mango varieties covering almost all the commercial strains. The plant material appears to be uniform and true to type.

## OBSERVATIONS AND RESULTS

### *Flowering time*

During 1957, an 'on' year for mango in the Punjab, it was observed that all the grafted varieties bore medium to heavy flowering. Among the important varieties, Dusehri carried the heaviest flowering, while Langra had only medium to heavy flowering.

The flowering in important mango varieties was observed to commence as under:

| | |
|---|---|
| Dusehri | 4th week of February |
| Langra | 1st and 2nd week of March |
| Fajri | —do— |
| Samarbehisht Chowsa | 1st week of March |
| Bombay Yellow | —do— |
| Khas-ul-Khas | —do— |

It was observed that at comparatively hot places like Jullundur and Amritsar, flowering had commenced one to two weeks earlier. The flowering was mostly over by the end of March, but in late varieties, like Fajri and Samarbehisht Chowsa, it continued for a week or so more.

### *Panicle development*

Observations on the panicle development were recorded in four varieties, namely, Dusehri, Fajri, Samarbehisht Chowsa and Bombay Yellow. In all, 20 healthy panicles in each variety (ten hanging in the open and the remaining ten in shady portion) were selected at random and labelled on March 13, when they had already attained a good size. The growth in the length of panicles was recorded on alternate days, and the data thus obtained are summarized in Table I.

TABLE I. GROWTH OF PANICLES HANGING IN 'OPEN' AND IN 'SHADE' IN MANGO VARIETIES

| Date | Elongation growth (in cm.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Dusehri | | Bombay Yellow | | Fajri | | Samarbehisht Chowsa | |
| | Open | Shade | Open | Shade | Open | Shade | Open | Shade |
| 13/3 | 17·95 | 6·20 | 13·85 | 5·95 | 17·90 | 5·50 | 18·95 | 5·30 |
| 17/3 | 20·15 | 10·18 | 19·40 | 10·85 | 19·55 | 9·33 | 24·00 | 9·20 |
| 21/3 | 22·80 | 16·95 | 23·20 | 16·00 | 21·80 | 14·35 | 27·40 | 15·15 |
| 25/3 | 22·40 | 19·55 | 24·35 | 17·60 | 22·30 | 16·70 | 28·60 | 18·70 |
| 29/3 | 22·40 | 20·15 | 24·70 | 19·30 | 22·20 | 18·75 | 29·10 | 20·95 |
| 2/4 | 22·50 | 20·60 | 25·15 | 19·95 | 22·45 | 19·85 | 28·80 | 22·25 |
| 4/4 | 22·55 | 20·70 | 25·15 | 19·95 | 22·45 | 20·00 | 28·90 | 22·50 |

As is seen from Table I, that the panicles from open and shady portions of the tree behaved in different manners. While the panicles from the open portion of the trees had emerged much earlier and registered a rather slow growth during the period under study, panicles from the shady portion were late in emergence but made extension growth at a faster rate. During the first week of April, panicles of both the categories ceased making further extension growth, which clearly showed that their flowering was completely over by that time. The behaviour of all the four varieties appeared to be similar though there were differences in panicle size. It was further seen that the panicles hanging in the exposed portion of the tree were bigger than those in the shady portion.

The ultimate size of the panicles in length and breadth was measured in five varieties, and the data are set out in Table II.

TABLE II. PANICLE SIZE IN DIFFERENT MANGO VARIETIES

| Variety | Length (cm.) | Breadth (cm.) |
|---|---|---|
| Dusehri | 22·72 | 14·40 |
| Langra | 23·13 | 13·60 |
| Khas-ul-Khas | 23·88 | 12·45 |
| Fajri | 21·49 | 10·80 |
| Samarbehisht Chowsa | 25·09 | 13·76 |

In each variety, one hundred full-grown panicles were picked up at random for this purpose. The figures given in Table II are the averages for each variety. As seen from the data regarding the size of the panicles, it is found that the panicle of Samarbehisht Chowsa had the maximum size, both with regard to length and breadth, while Fajri had the smallest-sized panicle. The panicle of Dusehri had the largest width (Fig. 1). So far as fruit size is concerned, Fajri has the largest fruit and Dusehri

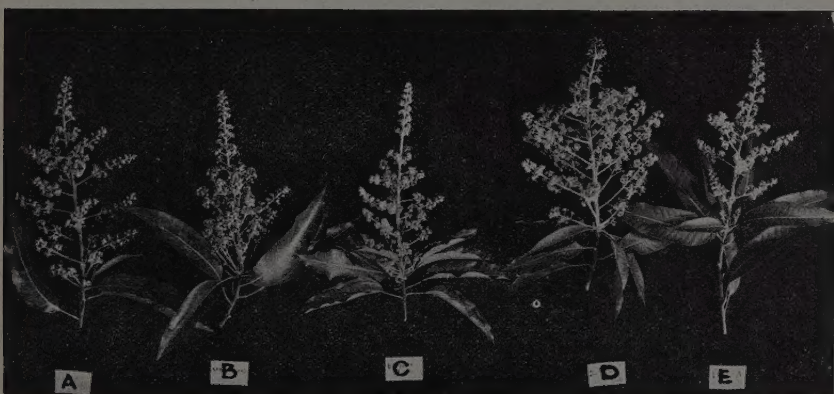


FIG. 1. PANICLES OF DIFFERENT MANGO VARIETIES
A-BRIDE OF RUSSIA; B-KHAS-UL-KHAS; C-BOMBAY YELLOW; D-DUSEHRI, E-LANGRA

the smallest. It is apparent that the panicle size has no relation with fruit size. It may also be added that mixed inflorescence, i.e., panicles having leaves, were observed in the Fajri and Samarbehisht Chowsa varieties (Fig. 2).


FIG. 2. NORMAL AND MIXED TYPES OF PANICLES
F (left)-MIXED PANICLE OF FAJRI; F (right)-NORMAL PANICLE OF FAJRI; G (left)-MIXED PANICLE OF SAMARBEHISHT CHOWSA; G (right)-NORMAL PANICLE OF SAMARBEHISHT CHOWSA

*Fruit-set*

It is a common feature in mango that in spite of profuse flowering, the fruit harvest may remain meagre. In order to find out the extent of fruit-set and its actual retention per panicle, a study was carried out on 15 varieties. Ten average-sized panicles were tagged in each variety, in the first week of April, when the fruit-set had started. The fruit borne on the selected panicles was counted everyday. The data are reported in Table III.

A study of the data given in Table III reveals that very little fruit per panicle is actually retained up to the time of harvest. Though an average number of 28·8 fruits per panicle were counted in the first week of April, only an average number of 0·4 fruit per panicle was left by June 30, when the fruit had neared maturity. The original setting of fruit does not appear to have any relation to the fruit actually retained at the end of the season. The data further indicate that the fruit retention power of different varieties varies. For instance, in varieties like Safeda Malihabad, Bombay Yellow and Channa Mian Sahib, 1·0 to 1·5 fruits per panicle were retained, but in the case of Langra, Kishan Bhog and Bride of Russia, no fruit on the marked panicles was retained which indicates their very low retentive power.

*Rate and extent of fruit-drop*

In order to find out the rate and extent of fruit-drop and to assess the shedding during different periods, studies on fruit-drop in eight varieties were carried out, commencing April 7, 1957. The data are reported in Table IV. One representative and full-grown tree of each variety was taken for these studies. The analysis of fruit-

TABLE III. PERIODIC FRUIT COUNTS ON TAGGED PANICLES IN 15 MANGO VARIETIES

| Variety | Average count of fruit on different dates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | April | | | | May | | | June | |
| | 6 | 15 | 22 | 30 | 8 | 16 | 30 | 15 | 30 |
| Dusehri | 36·0 | 24·2 | 13·3 | 4·1 | 2·5 | 1·0 | 0·5 | 0·4 | 0·4 |
| Langra | 67·4 | 11·9 | 4·0 | 1·9 | 0·6 | 0·2 | .. | .. | .. |
| Fajri | 24·9 | 9·6 | 7·7 | 3·9 | 2·6 | 1·1 | 0·3 | 0·2 | 0·2 |
| Samarbehisht Chowsa | 24·2 | 10·0 | 2·7 | 1·0 | 0·1 | 0·1 | 0·1 | 0·1 | 0·1 |
| Bombay Yellow | 20·2 | 27·2 | 8·2 | 4·7 | 3·1 | 1·6 | 1·2 | 1·0 | 1·0 |
| Khas-ul-Khas | 31·2 | 8·9 | 3·9 | 3·2 | 1·7 | 0·8 | 0·5 | 0·5 | 0·5 |
| Kishan Bhog | 21·9 | 31·8 | 16·2 | 4·7 | 2·4 | 1·2 | 0·7 | 0·1 | .. |
| Safeda Malihabad | 15·6 | 11·0 | 9·2 | 6·8 | 3·6 | 2·3 | 1·5 | 1·5 | 1·5 |
| Hussanara | 8·5 | 6·6 | 1·8 | 0·2 | 0·1 | 0·1 | .. | .. | .. |
| Rataul | 9·9 | 11·6 | 8·4 | 5·5 | 2·5 | 1·9 | 1·0 | 0·5 | 0·5 |
| Bride of Russia | 28·9 | 14·4 | 9·7 | 4·1 | 0·7 | 0·5 | .. | .. | .. |
| Alphonso | 18·9 | 12·4 | 7·6 | 3·2 | 1·0 | 0·6 | 0·5 | 0·4 | 0·3 |
| Channa Mian Sahib | 38·0 | 30·3 | 17·7 | 11·1 | 4·9 | 3·8 | 1·4 | 1·2 | 1·0 |
| Mohammad Wala | 29·7 | 26·0 | 17·3 | 0·4 | 0·2 | 0·1 | 0·1 | 0·1 | 0·1 |
| Gulab Jaman | 57·1 | 74·7 | 45·1 | 11·9 | 5·9 | 2·0 | 1·0 | 0·7 | 0·7 |
| Total | 432·4 | 310·6 | 172·8 | 66·7 | 31·9 | 17·8 | 8·8 | 6·7 | 6·3 |
| Average | 20·8 | 20·7 | 11·5 | 4·4 | 2·1 | 1·2 | 0·6 | 0·4 | 0·4 |

drop data reported in Table IV shows that the major fruit-drop, on the basis of counts of the sheds, occurred during the month of April. In May, the rate of drop decreased considerably. In June, when the fruit approached maturity, the rate of drop decreased to the lowest level.

### *Sex distribution*

Studies on sex distribution were carried out in the case of five varieties. In each variety, five panicles on one representative tree were selected and labelled. The counting of perfect and male flowers was done twice daily from March 14 to the middle of April, when the flowering was completely over. After every count, the counted flowers of either sex were removed gently with the help of forceps to avoid their recounting.

The relative sex counts presented in Table V show that the total number of flowers and their distribution in perfect and male flowers varies considerably with different

TABLE IV. AVERAGE FRUIT-DROP PER DAY IN EIGHT VARIETIES OF MANGO

(April 7 to June 30, 1957)

| Period | Dusehri | Khas-ul-Khas | Bombay Yellow | Langra | Fajri | Samar-behisht Chowsa | Bride of Russia | Alphonso |
|---|---|---|---|---|---|---|---|---|
| April 7–13 | 631 | 84 | 163 | 171 | 46 | 47 | 199 | 52 |
| ,, 14–20 | 284 | 101 | 123 | 88 | 90 | 87 | 81 | 71 |
| ,, 21–27 | 498 | 99 | 93 | 172 | 108 | 73 | 130 | 92 |
| ,, 28-4th May | 980 | 67 | 62 | 186 | 125 | 50 | 320 | 91 |
| May 5–11 | 287 | 76 | 41 | 268 | 219 | 72 | 318 | 70 |
| ,, 12–18 | 225 | 78 | 35 | 99 | 153 | 17·3 | 153 | 34 |
| ,, 19–25 | 88 | 19·1 | 28 | 47 | 88 | 2·0 | 70 | 17·4 |
| ,, 25-1st June | 39 | 9·4 | 15·4 | 34 | 88 | 1·7 | 27 | 13·3 |
| June 2–8 | 10 | 3·0 | 6·7 | 9·6 | 12 | 1·3 | 6·9 | 3·9 |
| ,, 9–15 | 7·1 | 0·1 | 4·6 | 0·7 | 4·1 | 0·7 | 1·6 | 3·0 |
| ,, 16–22 | 13 | 0·9 | 5·3 | 3·0 | 6·6 | 3·0 | 7·4 | 3·6 |
| ,, 23–30 | 2·6 | 0·7 | 1·8 | 0·4 | 0·9 | 0·7 | 1·7 | 0·7 |

varieties. The panicle of Dusehri was found to contain the largest number of flowers—1,468. This variety had also the least number of perfect flowers. Another notable point emerging from these studies is that in the beginning of the flowering season (March 14 to March 21) relatively greater number of perfect flowers (41·2 per cent) appeared. However, towards the end of the flowering season, an overwhelming majority of male flowers was noticed in all the varieties, the percentage varying from 76·9 to 83·9 during the period March 22 to April 10. Taking into account all the varieties, the relative percentages of perfect and male flowers were found to be 28·3 and 71·7, respectively.

*Time of anthesis*

The observations on the opening of flowers were also recorded twice daily at 10 a.m. (forenoon) and 4 p.m. (afternoon). The results in respect of five important varieties are reported in Table VI.

The data presented in Table VI show that majority of flowers, both perfect and male, opened by 10 a.m. On percentage basis, 72·2 to 81·9 per cent flowers opened by 10 a.m. and the rest in the afternoon by 4 p.m. There was not much difference in the behaviour of anthesis in the different varieties studied. The sex-ratio had also no specific relationship with the time of opening of flowers.

TABLE V. NUMBER OF PERFECT AND MALE FLOWERS IN FIVE VARIETIES OF MANGO DURING 1957

| Variety | Period of studies | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | March 14 to 21 | | | March 22 to 29 | | | March 30 to April 10 | | | Grand total | | |
| | Perf. | Male | Total | Perf. | Male | Total | Perf. | Male | Total | Perf. | Male | Total |
| Dusehri | 204 | 420 | 624 | 35 | 624 | 659 | 1 | 184 | 185 | 240 | 1,228 | 1,468 |
| Fajri | 175 | 100 | 275 | 123 | 321 | 444 | 10 | 224 | 234 | 308 | 645 | 953 |
| Langra | 157 | 27 | 184 | 180 | 96 | 276 | 132 | 138 | 270 | 469 | 261 | 730 |
| Bombay Yellow | 122 | 473 | 595 | 42 | 222 | 264 | 2 | 7 | 9 | 166 | 702 | 868 |
| Samarbehisht Chowsa | 128 | 99 | 227 | 109 | 362 | 471 | 38 | 391 | 429 | 275 | 852 | 1,127 |
| Total | 786 | 1,119 | 1,905 | 489 | 1,625 | 2,114 | 183 | 944 | 1,127 | 1,458 | 3,688 | 5,146 |
| Mean | 157·2 | 223·8 | 381·0 | 97·8 | 325·0 | 422·8 | 36·6 | 188·8 | 225·4 | 291·6 | 737·6 | 1,029·2 |
| Percentage | 41·2 | 58·8 | 100·0 | 23·1 | 76·9 | 100·0 | 16·1 | 83·9 | 100·0 | 28·3 | 71·7 | 100·0 |

TABLE VI. RATE OF ANTHESIS OF FLOWERS IN FIVE MANGO VARIETIES DURING 1957

| Variety | Anthesis of flowers (by number) | | | Anthesis of flowers (percentage) | |
|---|---|---|---|---|---|
| | Forenoon | Afternoon | Total | Forenoon | Afternoon |
| Dusehri | 1,203 | 265 | 1,468 | 81·9 | 18·1 |
| Fajri | 805 | 148 | 953 | 84·5 | 15·5 |
| Langra | 553 | 177 | 730 | 75·8 | 24·2 |
| Bombay Yellow | 627 | 241 | 868 | 72·2 | 27·8 |
| Samarbehisht Chowsa | 873 | 254 | 1,127 | 77·5 | 22·5 |

## DISCUSSION

Studies on the floral biology have yielded certain interesting results. The flowering period for most of the mango varieties in the Punjab is during the month of March as compared to January-March in Bihar (Mallik, 1957) and January-February in U.P. as reported by Singh (1954b). The process of panicle elongation was found to continue up to the first week of April after which there was no growth. This finding is in conformity with that reported by Musahib-ud-Din and Dhinsa (1946) in the case of the Langra variety under Lyallpur (West Pakistan) conditions.

The panicle size varied with the variety. Samarbehisht Chowsa had the longest panicle, while the panicle of Fajri was the smallest of all. These observations generally agree with those reported by Mallik (*loc. cit.*).

Mixed panicles were noted in Fajri and Samarbehisht Chowsa which are late-maturing. These varieties appear to have some tendency for regular bearing, and the presence of mixed panicles may have some relationship with the regular bearing tendency as opined by Mallik (*loc. cit.*).

The finding, that on an average only 0·4 fruit was ultimately retained per panicle at harvest, is of great significance. It leads to the conclusion that for getting enough crossed fruits in mango breeding work, a large number of panicles are required to be handled. In the case of mango, since one fruit yields only one stone, the enormity of the problem is really great. Musahib-ud-Din and Dhinsa (*loc. cit.*) and Singh (1954b) also found almost the same number of fruits per panicle left in the full-grown stage. It has been observed that the panicles hanging on the periphery of the tree are always bigger as compared to those hanging inside. The latter start growing later, but their growth is completed along with the panicles on the periphery.

Studies on fruit-drop have shown that the major drop in mango occurs in the month of April when the fruit is still young. This drop is possibly due to the competition for food supply. The tree cannot feed numerous fruits and hence large numbers are shed. The rate of fruit-drop in May is also quite high, probably due to the hot and strong winds experienced in the Punjab during this month. The rate of fruit-drop lessens in June as the fruit reaches maturity. The general notion that in the Langra

variety there is comparatively greater fruit-drop is not confirmed by these studies. On the other hand, data presented show that in some other varieties like Dusehri, Bride of Russia, etc., the rate and extent of fruit-drop was much higher. There was a relatively heavier drop in the trees or varieties in which the initial load of fruit-set was greater. The tree sheds away fruit beyond its carrying capacity, depending upon its age, state of health, nutrition, etc. The varietal character also appears to play a role.

Studies on sex distribution have shown that there is a lot of variation in the number of perfect and staminate flowers in different varieties. Out of the varieties studied, Langra was found to have the highest percentage of perfect flowers (64·2 per cent). Dusehri had the largest number of flowers per panicle, but the percentage of perfect flowers was only 16·3. Singh (1954b) working at Saharanpur, recorded similar results. He found that perfect flowers in Dusehri and Langra were 30·6 and 69·8 per cent, respectively. A very low percentage of perfect flowers, varying from 16·41 in Neelum to 3·47 in Alampur Beneshan, has been reported by Naik and Rao (1943) from South India. Mallik (1957) has reported that the percentage of perfect flowers in the case of Bombay, Langra and Fajri was 9·2, 43·4 and 14·9 per cent, respectively, during the 'on' year. It may be concluded that there is no fixed ratio between perfect and male flowers in different mango varieties growing in different parts of the country. Experimental evidence recorded elsewhere and through the present studies shows that Langra has the maximum percentage of perfect flowers and, consequently, a very low sex ratio. Singh (1957) reports that varieties with a high sex ratio, i.e., having a lower percentage of perfect flowers, tend to bear regularly though the yields are low. That explains to some extent the acute phenomenon of alternate bearing in varieties like Langra, Fajri and Dusehri which have a low sex ratio.

In the beginning of the season, a higher percentage of hermaphrodite flowers opened out, while towards the end of the flowering season, majority of the flowers that opened were male. These results are in conformity with the findings of Singh and Tomar (1949) who worked on *kaghzi* lime and Singh and Dhuria (1960) who have reported work on sweet lime. It is very impotant, therefore, that for getting better results in mango crossing, attempts should be made in the earlier part of the season.

In these studies, the maximum of anthesis, both of male and perfect flowers, has been observed to occur in the forenoon. Most of the previous workers like Popenoe (1917), Wagle (1928, 1929), Sen *et al.* (1946), Musahib-ud-Din and Dhinsa (1946), Singh (1954b), Singh and Dhuria (1960) have also reported that the maximum opening of flowers takes place in the forenoon. As such the present findings confirm the results of previous workers. It is suggested, therefore, that necessary manipulations of flowers for crossing work may be done during the morning hours only for obtaining better results.

SUMMARY

Studies on the floral biology and fruit-drop of different varieties of mango were conducted during the flowering and fruiting season of 1957 at the Government Garden, Qadian, District Gurdaspur, Punjab.

The flowering in the important varieties was found to commence from the end of February to middle of March. Being an 'on' year for mangoes, almost all the varieties bore medium to heavy flowering.

The panicle development was studied in the case of four varieties. It was observed that the elongation growth of panicles ceased completely by the first week of April in all the varieties. The size of panicles varied with the variety and also with its hanging position on the tree. Mixed panicles were noticed in Fajri and Samarbehisht Chowsa.

On an average, only 0·4 fruits per panicle were retained at the time of harvest. This heavy shedding in mangoes necessitates the employment of a large number of panicles for crossing work to obtain measurable success.

The major fruit-drop occurs in the young stage during the month of April. The intensity of fruit-drop in May is also quite high. The rate of fruit-drop declines progressively in June as the fruit approaches maturity.

Studies on sex distribution have revealed great variation in the number of perfect and male flowers in different varieties. Langra was found to have the highest percentage of perfect flowers (64·2 per cent). The panicle of Dusehri had the maximum number of flowers, but the percentage of perfect flowers in this variety was 16·3 only.

During the earlier part of the flowering season, the proportion of perfect flowers was high while later on most of the flowers that opened were male. For better results in crossing, the early part of the season may, therefore, be availed of.

The usual time of anthesis, both in the case of male and perfect flowers, has been observed to be the forenoon when more than 79 per cent of the flowers were found to open on any day.

## ACKNOWLEDGEMENTS

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# PRELIMINARY STUDIES ON THE EFFICACY OF DIFFERENT NITROGENOUS FERTILIZERS FOR COTTON, *JOWAR* AND WHEAT AT INDORE

S. S. VERMA

*Regional Research Centre, Amravati*

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THE remarkable increase in crop yields obtained with the application of artificial fertilizers has convinced the farmers of their positive utility in crop production. Consequently, the demand for these fertilizers has increased so much that the fertilizer industry is not able to keep pace with it at the present rate of production, especially in the case of ammonium sulphate which is widely used in India. In recent years, other forms of nitrogenous fertilizers have also been considered as alternatives for agricultural purposes, and one of them, ammonium chloride, appears to be cheaper and as efficient as the other forms of nitrogenous fertilizers, particularly ammonium sulphate, for most crops. The results of these investigations have been reviewed by Raychaudhuri and Biswas (1956) and Desai (1956).

In order to assess the relative efficacy of ammonium chloride and ammonium sulphate for major crops like cotton, *jowar* and wheat grown in the black cotton soils of the Malwa plateau, experiments were conducted at the Institute of Plant Industry, Indore. In these experiments, other forms of nitrogen, namely, ammonium sulphate nitrate and urea, were also included for comparison.

## MATERIAL AND METHODS

The trials referred to above were conducted on *desi* cotton (Bhoj) and *jowar* (IPI 3) separately for two seasons (1956-57 and 1957-58) under rainfed conditions. These crops were sown in rows 14 in. apart at the break of the monsoon. The seeding rates were 20 lb. and 10 lb. per acre for cotton and *jowar*, respectively.

A month after germination, thinning was done to have a plant-to-plant distance of 6 to 9 in. in *desi* cotton and about 12 in. in *jowar*. In each crop, the four nitrogenous fertilizers, namely, ammonium chloride (25 per cent N), ammonium sulphate (20 per cent N), ammonium sulphate nitrate (25 per cent N) and urea (45 per cent N) were applied on equal nitrogen basis at 0, 30, 60 and 90 lb. N per acre, except that the ammonium sulphate nitrate could not be applied to *jowar* in 1957-58. The treatments were randomized in a simple randomized block design with four replications and 1/156 acre net plot size. The experimental site was also different for the two crops in different seasons.

During the same two seasons (1956-57 and 1957-58), the trials were laid out with two varieties of wheat—EK 69 and NP 710, which were sown in the last week of October in rows 14 in. apart.

The same four nitrogenous fertilizers were applied in four graded doses of 0, 20, 40 and 60 lb. N per acre and 0, 15, 30 and 45 lb. N under irrigated and *barani* conditions,

respectively. These trials were laid out in a split plot design with varieties in the main plots and the combinations of forms and doses of nitrogen in subplots. There were two replications with 1/156 acre net subplot for irrigated wheat and four replications with 1/124 acre net subplot for rainfed wheat.

In all the crops under experimentation, the full dose of the fertilizers was applied as a basal dressing at the time of sowing as per findings of Panse (1945).

## RESULTS AND DISCUSSION

Since the crop yield is the real index of the efficiency of fertilizers, the present paper deals with the yield data alone obtained through the application of different nitrogenous fertilizers. The statistical analysis of the yield data from cotton, *jowar* and irrigated wheat did not show significant interaction between the major factors constituting the treatments; the results, therefore, are discussed for the main effects only.

### *Cotton*

The yields of *kapas* (seed-cotton) obtained during the two seasons are given in Table I.

TABLE I. AVERAGE YIELD OF *KAPAS* IN LB. PER ACRE

| Season | Level of nitrogen (lb.) | | | | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | | |
| 1956–57 | 345 | 407 | 467 | 431 | ±21·8 | 61·8 |
| 1957–58 | 586 | 656 | 697 | 637 | ±29·3 | Not sig. |
| Mean | 464·5 | 531·5 | 582·0 | 534·0 | | |

KINDS OF NITROGEN

| Season | Amm. sulphate | Amm. sulphate nitrate | Urea | Amm. chloride | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|
| 1956–57 | 420 | 421 | 402 | 497 | ±25·4 | 72·0 |
| 1957–58 | 671 | 572 | 686 | 724 | ±33·8 | 96·0 |
| Mean | 545·5 | 496·5 | 544·0 | 610·5 | | |

From the above data it will be seen that the yield of *kapas* increased with an increase in the dosage of nitrogen up to 60 lb. N, and that a further dose of 90 lb. N indicated a depression in the yield in both the seasons. These differences, however,

were observed to be statistically significant over control during 1956-57 only. Panse (1945) reported appreciable increases in the yields of cotton with the application of nitrogen, both organic and inorganic forms. Singh and Simlote (1955) also noted a depressing effect in cotton yields due to doses higher than 60 lb. N per acre under similar conditions at Indore.

Among the four nitrogenous fertilizers, the application of ammonium chloride gave the highest yield of seed-cotton in both the seasons. In the year 1956-57, it proved significantly superior to other forms, while in the second year (1957-58) there were no significant differences in the yields obtained with the application of different forms except ammonium sulphate nitrate which was found significantly inferior in this respect. Skinner and Buic (1926) found that the sulphate and chloride forms of ammoniacal nitrogen are equally efficient for cotton. Desai (1956) also reported similar results on cotton grown in black soils at Hyderabad. In another series of experiments, conducted at Indore in 1958-59, the application of ammonium chloride gave significantly higher (15 per cent more) of cotton than that of ammonium sulphate applied on equal nitrogen basis (unpub.). These findings are, however, contrary to the results obtained on cotton in North Carolina where ammonium nitrate, ammonium phosphate or urea have proved as efficient as ammonium sulphate or sodium nitrate, but all of them produced larger yields than ammonium chloride (Christidis and Harrison, 1955). It seems that in the black cotton soil with a pH range of 8·0 to 8·5, ammonium chloride, which is more acidic than the other fertilizers (Bear, 1953) used in these investigations, is superior in the following ways: almost all the nitrogen absorbed from ammonium chloride is retained by the soil which, on the other hand, loses much of the nitrogen absorbed from ammonium sulphate (Sen, 1956); it may be accelerating the uptake of other essential nutrients like P, K, Ca and Mg through its buffering action in the soil.

*Economics of fertilization:* The dose and form of fertilizer for practical use will be the one which has proved most economic in its application. Such calculations have been done and the figures for average yields of different fertilizers at different levels and their responses with profit or loss are given in Tables II and III, respectively.

TABLE II. *KAPAS* YIELD IN LB. PER ACRE (AVERAGE OF TWO SEASONS)

| Fertilizer | Level of nitrogen (lb.) | | | Mean for fertilizer |
|---|---|---|---|---|
| | 30 | 60 | 90 | |
| Ammonium sulphate | 544 | 604 | 490 | 546 |
| Ammonium sulphate nitrate | 499 | 506 | 485 | 497 |
| Urea | 499 | 614 | 519 | 544 |
| Ammonium chloride | 583 | 606 | 643 | 611 |
| Mean for levels | 531 | 582 | 534 | |
| No fertilizer | 465 | | | |

TABLE III. ECONOMICS OF FERTILIZATION

| Fertilizer | Response to 30 lb. N per acre (lb.) | Value of produce (Rs.) | Cost of fertilization per acre (Rs.) | Net profit (+) or loss (—) with 30 lb. N per acre (Rs.) | Response to 60 lb. N (lb.) | Value of produce (Rs.) | Cost of fertilization per acre (Rs.) | Net profit (+) or loss (—) with 60 lb. N per acre (Rs.) | Response to 90 lb. N per acre (lb.) | Value of produce (Rs.) | Cost of fertilization per acre (Rs.) | Net profit (+) or loss (—) with 90 lb. N per acre (Rs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amm. sulphate | 79 | 28·91 | 26·94 | + 1·97 | 139 | 50·87 | 52·88 | — 1·51 | 25 | 9·15 | 77·82 | —68·67 |
| Amm. sulphate nitrate | 34 | 12·44 | 25·87 | —13·43 | 41 | 15·00 | 50·24 | —35·24 | 20 | 7·32 | 74·61 | —67·29 |
| Urea | 34 | 12·44 | 20·84 | — 8·40 | 149 | 54·53 | 40·18 | +14·35 | 54 | 19·76 | 59·52 | —39·76 |
| Amm. chloride | 118 | 43·19 | 21·86 | +21·33 | 141 | 51·60 | 42·22 | + 9·38 | 178 | 65·15 | 62·58 | + 2·57 |

Price of amm. sulphate @ Rs. 380 per ton, including transportation
,, amm. chloride @ Rs. 380 —do—
,, urea @ Rs. 650 —do—
,, amm. sulphate nitrate @ Rs. 455 —do—
Cost of application @ Rs. 1·50 per acre.
Value of *kapas* @ Rs. 30 per maund (82 lb.)

It will be noted from figures given in Table III that the magnitude of response at all levels was the lowest with the application of ammonium sulphate nitrate. The differences in response due to the application of the remaining three fertilizers, namely, ammonium sulphate, urea and ammonium chloride, at the medium dose of 60 lb. N were not appreciable, while at the levels of 30 and 90 lb. N, these were quite marked with ammonium chloride which gave the highest response—118 and 178 lb., respectively.

In terms of monetary gains, the application of ammonium sulphate nitrate proved uneconomic at all levels. The doses of 30 and 60 lb. N in the form of ammonium sulphate and urea, respectively, were found economic in each of these two fertilizers, while the application of ammonium chloride proved economic at all levels although the margin of profit decreased with an increase in the dosage. The highest profit of Rs. 21·33 per acre was obtained with the application of ammonium chloride at 30 lb. N per acre, and the next in order was urea applied at 60 lb. N per acre.

### *Jowar*

The average yields of both grain and *karbi* (dry fodder) of *jowar* (*Sorghum vulgare*) are given in Table IV.

TABLE IV. AVERAGE YIELD IN LB. PER ACRE

| Season | Produce | Level of nitrogen (lb.) 0 | 30 | 60 | 90 | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|---|
| 1956–57 | Grain | 826 | 1,193 | 1,053 | 1,465 | ± 76 | 216 |
| | *Karbi* | 3,742 | 4,590 | 5,534 | 7,080 | ±320 | 910 |
| 1957–58 | Grain | 1,730 | 1,738 | 1,999 | 2,139 | ±115 | 329 |
| | *Karbi* | 8,115 | 9,709 | 8,225 | 8,362 | ±610 | Not sig. |
| Mean | Grain | 1,274 | 1,465 | 1,526 | 1,802 | | |
| | *Karbi* | 5,928 | 7,149 | 6,879 | 7,721 | | |

KINDS OF NITROGEN

| Season | Produce | Amm. sulphate nitrate | Urea | Amm. chloride | Amm. sulphate | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|---|
| 1956–57 | Grain | 1,118 | 1,246 | 1,275 | 1,310 | ± 88 | Not sig. |
| | *Karbi* | 5,081 | 5,939 | 6,030 | 5,887 | ±369 | Not sig. |
| 1957–58 | Grain | .. | 1,969 | 1,907 | 2,000 | ±115 | Not sig. |
| | *Karbi* | .. | 9,716 | 7,979 | 8,601 | ±610 | Not sig. |
| Mean | Grain | 1,118 | 1,607 | 1,591 | 1,655 | | |
| | *Karbi* | 5,081 | 7,827 | 7,004 | 7,244 | | |

The application of nitrogen in *jowar* increased its grain as well as *karbi* yields. In 1956-57, the grain outturn from the control (unmanured) plot was significantly the lowest while that with a dose of 90 lb. N was significantly the highest as compared to the other doses. The doses of 30 and 60 lb. N, however, did not show any significant difference in their grain yields. In the second year (1957-58), the application of graded doses of nitrogen gave a linear response in grain production. The yield from 90 lb. N was significantly higher than that of control or 30 lb. N although these doses did not differ significantly with the dose of 60 lb. N.

For the production of *karbi*, the effect of nitrogen application was found to be statistically significant in one season (1956-57) only, wherein the yield of *karbi* increased significantly with a corresponding increase in the levels of nitrogen, except that of 30 lb. N over control.

Similar increases in yield have been reported by Nelson (1952) who obtained an increase of 31·4 and 40·9 bushels per acre with 80 and 160 lb. N per acre, respectively, over no-nitrogen plots. Pandey *et al.* (1954), while reviewing the work done on *jowar* in the erstwhile Bombay State, also reported a linear response in the grain yield of *jowar* due to the application of graded doses of nitrogen (20 lb. to 60 lb. N per acre).

The differences in grain and *karbi* yields of *jowar* due to different fertilizers were not significant. However, there was an indication of the poor performance of ammonium-sulphate nitrate, probably due to the leaching of nitrates in the early stages of plant development when adequate roots have not developed for the maximum utilization of the available nitrates incorporated through this fertilizer. Bear (1953) found that the nitrate forms of nitrogen carriers have low retentivity in the soil as compared to other carriers. It is also supported by Miller and Turk (1951), Collings (1955) and Abichandani and Patnaik (1958). In another series of experiments conducted at Indore during 1958-59, the application of 90 lb. N in the form of ammonium sulphate or ammonium chloride gave the highest yield of grain, and the two fertilizers did not differ significantly from each other (unpub.).

It is interesting and noteworthy that the application of ammonium chloride in cotton seemed to be more effective than the other forms of nitrogen, while in *jowar* all the four forms behaved alike. It appears that it is perhaps the difference in the pH of the root excretions from cotton and *jowar* that contributes to the differential behaviour of these fertilizers used in the two crops.

*Economics of fertilization*: In calculating the economics of fertilizer application, the data for ammonium sulphate nitrate, which was applied in one season only, has been excluded. The figures for average yields of grain and *karbi* obtained with the application of different fertilizers at different levels and their responses along with profit or loss, are given in Tables V and VI, respectively.

The figures in Table V have indicated a high magnitude of response when any of the three fertilizers was applied at 90 lb. N, the highest being with ammonium sulphate and urea. It is also noticed that the application of urea produced vegetatively vigorous plants since the *karbi*:grain ratio with it was the highest at all levels as compared to the corresponding levels of the other two fertilizers.

TABLE V. AVERAGE YIELD OF *JOWAR* IN LB. PER ACRE

| Fertilizer | | Level of nitrogen (lb.) 30 | 60 | 90 | Mean for fertilizer |
|---|---|---|---|---|---|
| Amm. sulphate | Grain | 1,555 | 1,487 | 1,923 | 1,655 |
| | *Karbi* | 7,535 | 6,544 | 7,653 | 7,244 |
| *Karbi* : grain ratio | | 4·8 | 4·4 | 3·9 | 4·4 |
| Urea | Grain | 1,356 | 1,522 | 1,944 | 1,607 |
| | *Karbi* | 7,380 | 7,545 | 8,557 | 7,827 |
| *Karbi* : grain ratio | | 5·4 | 4·9 | 4·4 | 4·9 |
| Amm. chloride | Grain | 1,583 | 1,584 | 1,606 | 1,591 |
| | *Karbi* | 6,709 | 7,059 | 7,244 | 7,004 |
| *Karbi* : grain ratio | | 4·2 | 4·4 | 4·5 | 4·4 |
| No fertilizer | Grain | 1,292 | | | |
| | *Karbi* | 6,002 | | | |
| *Karbi* : grain ratio | | 4·6 | | | |

A perusal of Table VI will reveal that the application of any of the three fertilizers was found economic at levels used in the experiment except ammonium sulphate at 60 lb. N, which is only by chance. The maximum profits of Rs. 115·19 and Rs. 70·72 were obtained with the application of urea and ammonium sulphate, respectively, at 90 lb. N per acre; next in order were Rs. 56·09 and Rs. 45·28 with ammonium sulphate and ammonium chloride, respectively, at 30 lb. N per acre. The optimum dose of 90 lb. N as urea or ammonium sulphate is an improvement over the results of the past experiments which have indicated 20 to 40 lb. N as the optimum dose (Stewart, 1947) in major *jowar*-growing tracts of the country. Pandey *et al.* (1954) reported 60 lb. N and 20 lb. $P_2O_5$ as the optimum dose for *jowar* in the erstwhile Bombay State.

*Wheat*

The results on wheat are based on the data collected in one season (1956-57) only, because during the second year of the trial the conditions were abnormal in respect of the moisture status of the soil—the rainfall during September was much below the normal (2·99 in. against 6·50 in.), and the crop was also damaged by rats. The yields of grain obtained under irrigated and rainfed conditions during 1956-57 are given in Tables VII and VIII, respectively.

TABLE VI. ECONOMICS OF FERTILIZER APPLICATION IN *JOWAR*

| Fertilizer | produce | Response to 30 lb. N per acre (lb.) | Value of produce (Rs.) | Cost of fertilization per acre (Rs.) | Net profit (+) or loss (—) with 30 lb. N per acre (Rs.) | Response to 60 lb. N per acre (lb.) | Value of produce (Rs.) | Cost of fertilization per acre (Rs.) | Net profit (+) or loss (—) with 60 lb. N per acre (Rs.) | Response to 90 lb. N per acre (lb.) | Value of produce (Rs.) | Cost of fertilization per acre (Rs.) | Net profit (+) or loss (—) with 90 lb. N per acre (Rs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amm. sulphate | Grain | 263 | 44·71 | 26·94 | 56·09(+) | 195 | 33·15 | 52·38 | 5·68(—) | 631 | 107·27 | 77·82 | 70·72(+) |
| | *Karbi* | 1,533 | 38·32 | | | 542 | 13·55 | | | 1,651 | 41·27 | | |
| Urea | Grain | 64 | 10·88 | 20·84 | 24·49(+) | 230 | 39·10 | 40·18 | 37·47(+) | 652 | 110·84 | 59·52 | 115·19(+) |
| | *Karbi* | 1,378 | 34·45 | | | 1,543 | 38·55 | | | 2,555 | 63·87 | | |
| Amm. chloride | Grain | 291 | 49·47 | 21·86 | 45·28(+) | 292 | 49·64 | 42·22 | 33·84(+) | 314 | 53·38 | 62·58 | 21·85(+) |
| | *Karbi* | 707 | 17·67 | | | 1,057 | 26·42 | | | 1,242 | 31·05 | | |

Price of amm. sulphate @ Rs. 380 per ton, including cost of transportation
,, amm. chloride @ Rs. 380 per ton —do—
,, urea @ Rs. 650 per ton —do—
Cost of application @ Rs. 1·50 per acre
Value of *jowar* grain @ Rs. 14·00 per maund (82 lb.)
,, ,, *karbi* @ Rs. 2·00 per maund (82 lb.)

TABLE VII. AVERAGE YIELD OF GRAIN IN LB. PER ACRE (IRRIGATED)

| Level of N (lb.) | Variety | Amm. sulphate nitrate | Amm. sulphate | Urea | Amm. chloride | Mean | Overall mean for N | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|---|---|---|
| 60 | EK 69 | 1,847 | 1,456 | 1,494 | 1,899 | 1,674 | 1,794 | ±100 | Not sig. |
| | NP 710 | 2,248 | 1,792 | 1,383 | 2,211 | 1,909 | | | |
| 40 | EK 69 | 1,653 | 1,505 | 1,625 | 1,918 | 1,675 | 1,841 | | |
| | NP 710 | 2,215 | 2,059 | 1,608 | 2,414 | 2,006 | | | |
| 20 | EK 69 | 1,484 | 1,617 | 1,511 | 1,226 | 1,460 | 1,744 | | |
| | NP 710 | 2,189 | 1,850 | 2,230 | 1,842 | 2,028 | | | |
| Mean for fertilizer | | 1,939 | 1,713 | 1,642 | 1,873 | | | ±100 | Not sig. |
| Control | EK 69 | | | | | 1,519 | 1,573 | | |
| | NP 710 | | | | | 1,626 | | | |
| Mean for varieties | EK 69 | NP 710 | S.E. | C.D. at 5% | | | | | |
| | 1,582 | 1,892 | ±56 | Not sig. | | | | | |

The data as mentioned above did not show any significant difference in the yields of the two varieties although the magnitude of the difference was quite high. This may be due to the less number of degrees of freedom for its error. The yields of EK 69 were lower than those of NP 710 because all the plots with EK 69 were heavily infested with black rust resulting in shrivelled grains. The differences in yield due to different fertilizers or levels of nitrogen were also not significant although the application of nitrogen, in general, increased the grain yield as compared to untreated plots.

TABLE VIII. AVERAGE YIELD OF GRAIN LB. PER ACRE (RAINFED)

| Level of N (lb.) | Variety | Amm. sulphate nitrate | Amm. sulphate | Urea | Amm. chloride | Mean | Overall mean for N | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|---|---|---|
| 45 | EK 69 | 814 | 983 | 804 | 1,147 | 937 | 876 | ±32 | 90 |
| | NP 710 | 848 | 864 | 710 | 843 | 816 | | | |
| 30 | EK 69 | 924 | 826 | 938 | 1,083 | 942 | 853 | | |
| | NP 710 | 778 | 814 | 923 | 748 | 765 | | | |
| 15 | EK 69 | 913 | 785 | 831 | 753 | 820 | 849 | | |
| | NP 710 | 891 | 1,005 | 870 | 748 | 878 | | | |
| Mean for fertilizer | | 861 | 879 | 813 | 887 | | | ±32 | Not sig. |
| Control | EK 69 | .. | .. | .. | .. | 752 | 737 | | |
| | NP 710 | | | | | 723 | | | |
| Mean for varieties | | EK 69 | NP 710 | S.E. | C.D. | | | | |
| | | 858 | 795 | ±37 | Not sig. | | | | |

Under rainfed conditions, unlike the results obtained under irrigation, the variety EK 69 gave higher yield than NP 710 though not statistically significant. The application of nitrogen increased the yield of grain (112 to 139 lb. per acre) significantly over no-nitrogen plots, but there was no significant variation in grain outturn from different doses of nitrogen.

The production of wheat grain did not differ significantly with the application of different carriers of nitrogen. It was further observed that the two varieties behaved differently with respect to these fertilizers, as is seen from Table VIIIa.

TABLE VIIIa. INTERACTION, VARIETY × KINDS OF FERTILIZERS
(Grain in lb. per acre)

| Variety | Amm. sulphate nitrate | Amm. sulphate | Urea | Amm. chloride | S.E. | C.D. at 5% |
|---|---|---|---|---|---|---|
| EK 69 | 884 | 865 | 858 | 994 | ±45 | 127 |
| NP 710 | 839 | 894 | 768 | 778 | | |

The difference in the grain yield of the two varieties was higher with the application of urea and ammonium chloride and significantly so with the later as compared to that observed for ammonium sulphate nitrate or ammonium sulphate. Jain (1960) reported the superiority of ammonium chloride over ammonium sulphate and urea as regards yield, but it yielded less, though not significantly, due to less plant population as compared to other fertilizers under rainfed conditions at Sehore (M.P.).

## SUMMARY

The experiments mentioned in this article were conducted for two seasons (1956 and 1957) at Indore (M.P.) for determining the relative efficacy of four nitrogenous fertilizers applied in graded doses to cotton, *jowar* and wheat. The results are summarized below.

*Cotton*

Among the fertilizers, ammonium sulphate nitrate proved less effective and uneconomic at all levels.

The magnitude of response with the application of ammonium sulphate, urea or ammonium chloride at 60 lb. N was almost of the same order, while at 30 and 90 lb. N ammonium chloride gave the highest response of 118 and 178 lb. of *kapas* per acre, respectively.

The optimum dose of nitrogen for *desi* cotton was found to be 30 lb. per acre in the form of ammonium chloride.

*Jowar*

The variation in the grain or *karbi* yield of *jowar* obtained with the application of four nitrogenous fertilizers was not significant. Except ammonium sulphate nitrate,

which indicated a poor performance, the other fertilizers, namely, ammonium sulphate, urea and ammonium chloride, gave the highest response with 90 lb. N per acre.

In terms of monetary gains, the dose of 90 lb. N per acre as urea or ammonium sulphate proved optimum and gave the maximum net profits of Rs. 115·19 and Rs. 70·72 per acre, respectively.

*Wheat*

The yield of wheat was not affected significantly with the application of different doses or forms of nitrogen. However, the two varieties of wheat showed a differential response for different nitrogenous fertilizers wherein the yield from EK 69 was significantly higher than that of NP 710 with the application of ammonium chloride under rainfed conditions.

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# INHERITANCE STUDIES IN WHEAT

## XII. INHERITANCE OF SEEDLING REACTION TO PHYSIOLOGIC RACES 15 AND 21 OF *PUCCINIA GRAMINIS TRITICI* ERIKSS AND HENN. IN SOME INTERVARIETAL CROSSES OF *TRITICUM AESTIVUM* L.

S. M. SIKKA*, O. P. MAKHIJA and M. V. RAO

*Division of Botany, Indian Agricultural Research Institute, New Delhi*

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The present studies are a continuation of the work undertaken at the Botany Division of the Indian Agricultural Research Institute, to find out the mode of inheritance of seedling resistance to different physiologic races of the wheat rusts found in India. Studies carried out with physiologic races 24, 34, 40, 42, 75, and 117 and biotypes 21A and 42B of black rust (Rao and Agarwal, 1960a, b, c; Sikka *et al.*, 1961) and races 13 and H of yellow rust (Bahl and Kohli, 1960) have already been reported. Results obtained with the physiologic races 15 and 21 of *Puccinia graminis tritici* in certain crosses of the common bread wheat are reported here. Races 15 and 21 are some of the first races isolated by Mehta (1933) in India towards the early thirties. These races have a wide distribution in the country at present, occurring in most of the wheat-growing tracts.

### MATERIAL AND METHODS

The material consisted of the following intervarietal crosses of *Triticum aestivum* L.

E 871 (Tinstein × 2086) Sel. 1495A-1-31-2-1 × NP 718
E 952 (Rionegro) × Pb. C 518
NP 710 × NP 790
NP 775 × NP 790
Pb.C281 × NP 790
Pb.C518 × NP 790
NP 710 × E 581 (Kenya 184. P. 2. A. 1 F.)

NOTE: E refers to the accession numbers for the exotic wheats at the Indian Agricultural Research Institute and NP refers to the improved strains bred at the same institute.

In all these crosses, the $F_2$ generation was studied, except in the cross NP 775 × NP 790 where $F_3$ was also included. All the seven crosses were studied against race 21, whereas only the first two were studied against race 15.

All the varieties, both Indian and foreign, used in the present studies, have been described earlier by Sikka and Rao (1957) and Sikka *et al.* 1961.

The rust reactions of the varieties used in the present studies with races 15 and 21 of black rust are indicated below.

*At present, Additional Agricultural Commissioner with the Government of India.

| Variety | Type of reaction | |
|---|---|---|
| | 15 | 21 |
| E 581 | 0 | 0 |
| E 871 | 1 | 0,; |
| E 952 | 3, 4 | 0, 1 and 2 |
| Pb.C 281 | 4 | 4 |
| Pb.C 518 | 3 and 4 | 4 |
| NP 710 | 4 | 3 and 4 |
| NP 718 | 3 | 4 |
| NP 775 | 4 | 3 and 4 |
| NP 790 | 0,; | 0,; |

The salient features of the physiologic races of black rust used in this study are given below.

*Race* 15

Levine found this race in one of the collections sent to him from Pusa in the year 1933. Later, Mehta (1933) also isolated this race from the samples collected during 1930-32. At that time, on the basis of prevalence and distribution, this race was the second most important in India, next only to race 42.

*Race* 21

This race was the rarest of the six races identified by Mehta. This was isolated from only one collection from Lyallpur (now in West Pakistan) in the year 1933-34. Now the race is found in most of the wheat-growing tracts of the country.

The usual method of inoculation and recording as described by Sikka, Makhija and Rao (1961) was followed in these studies as well.

## RESULTS

*Inheritance of seedling reaction to race* 15 *of black rust*

Two crosses, viz., E 871 × NP 718 and E 952 × Pb.C 518, were studied to find out the mode of inheritance of seedling reaction to race 15. The results are presented in Table I.

TABLE I. INHERITANCE OF SEEDLING REACTION TO RACE 15 OF BLACK RUST IN $F_2$ OF TWO INTERVARIETAL CROSSES OF *T. AESTIVUM*

| Cross | Number of plants | | Total | $X^2$ | P value | Mode of segregation |
|---|---|---|---|---|---|---|
| | Resistant | Susceptible | | | | |
| E 871 × NP 718 | 185 | 66 | 251 | 0·218 | ·0·50–0·70 | 3R:1S |
| E 952 × Pb.C 518 | 51 | 229 | 280 | 0·0522 | 0·80–0·90 | 3R:13S |

In the case of the cross E 871 × NP 718, a single dominant gene appears to govern the seedling reaction to race 15. In the second cross, viz., E 952 × Pb. C 518, both the parents were susceptible to this race. The $F_2$ segregation into 3R:13S indicated the operation of an inhibitory factor and a factor for resistance.

*Inheritance of seedling reaction to race 21 of black rust*

The inheritance of seedling reaction to race 21 of black rust was studied in seven crosses and the data are presented in Table II.

TABLE II. SEEDLING REACTION IN $F_2$ OF SEVEN INTERVARIETAL CROSSES OF *T. AESTIVUM* TO RACE 21 OF BLACK RUST

| Cross | No. of plants | | Total | $X^2$ | P value | Mode of segregation |
|---|---|---|---|---|---|---|
| | Resistant | Susceptible | | | | |
| NP 718 × E 871 | 150 | 57 | 207 | 0·71 | 0·30–0·50 | 3R : 1S |
| E 952 × Pb.C 518 | 61 | 173 | 234 | 0·142 | 0·70–0·80 | 1R : 3S |
| NP 710 × E 581 | 99 | 7 | 106 | 0·0226 | 0·80–0·90 | 15R : 1S |
| NP 710 × NP 790 | 162 | 11 | 173 | 0·0008 | 0·95–0·98 | 15R : 1S |
| NP 775 × NP 790 | 228 | 19 | 247 | 0·0876 | 0·30–0·50 | 15R : 1S |
| Pb.C 281 × NP 790 | 216 | 66 | 282 | 0·383 | 0·50–0·70 | 3R : 1S |
| Pb.C 518 × NP 790 | 219 | 75 | 294 | 0·0408 | 0·80–0·90 | 3R : 1S |

From the above $F_2$ data it was seen that E 871 carried a single dominant gene for conditioning seedling resistance to race 21, while Kenya E 581 carried two duplicate genes. The resistance of E 952 (Rionegro) appeared to be controlled by a single recessive factor. NP 790 was found to differ from Pb.C 281 and Pb.C 518 by a single factor for resistance, while two duplicate genes appear to be involved in crosses with NP 710 and NP 775.

The $F_3$ of one cross, namely, NP 775 × NP 790 was also studied. Out of the total of 60 families studied, 27 were homozygous resistant, 29 segregated like the $F_2$ and 4 proved to be homozygous susceptible. With the P value ranging between 0·95 and 0·98, this gave a good fit to 7R:8H:1S according to expectation.

## DISCUSSION

Two crosses were studied against race 15 of black rust. In the cross E 871 × NP 718, a monohybrid segregation of 3R:1S was obtained, thereby indicating that E 871 (Timstein × 2086 Sel. 1495A-1-31-2-1) carries a single dominant gene for controlling the seedling resistance to this race. Similar results were obtained by Mehta (unpub. 1957) while working with the cross NP 789 (R) × Frondoso (S).

In the second cross, viz., E 952 (Rionegro) × Pb.C 518, both the parents were found to be susceptible to race 15. However, a segregation ratio of 3R:13S was obtained in the $F_2$ generation. These results can be explained on the assumption that E 952 carries an inhibitory gene along with a dominant gene for resistance to race 15, and Pb.C 518 the corresponding recessive alleles. On this basis, in the $F_2$ generation, those seedlings would be resistant which possess the dominant factor for resistance without the dominant inhibitor. These findings indicate the possibility of obtaining resistant segregates in crosses between susceptible varieties, which may be of commercial importance.

These results differ from those reported by some previous authors. Hynes (1926), while studying the cross Federation (S) × Khapli (R) for race 15, observed all gradations from resistance to susceptibility and interpreted his results on the multiple factor basis. In the cross NP 120(S) × Kenya E 144(R), two duplicate genes were found to govern seedling resistance to this race (Anon. 1948).

Seven crosses were studied for finding out the mode of inheritance of seedling reaction to race 21. Out of these, four crosses had the common resistant parent, viz., NP 790, while Kenya E 581, E 871 and Rionegro were the resistant parents involved in the other three crosses.

From the study of the cross NP 718 × E 871, it was found that E 871 carried a single dominant gene for resistance to race 21. In the cross E 952 × Pb.C 518, the reaction to this race was governed by a single recessive gene of E 952 (Rionegro). A segregation ratio of 15R:1S was obtained in the cross E 581 × NP 710, showing, thereby, the operation of two dominant duplicate genes for resistance. The results of the crosses NP 710 × NP 790 and NP 775 × NP 790 indicate that NP 790 carried two duplicate dominant genes governing resistance to race 21. This was further confirmed by the $F_3$ data of the cross NP 775 × NP 790, where a segregation ratio of seven homozygous resistant : eight segregating : one homozygous susceptible was obtained. However, NP 790 in crosses with Pb.C 281 and Pb.C 518, gave the 3R:1S ratio, indicating the operation of a single gene. These variable results obtained from the crosses of NP 790 with Punjab and N.P. wheats are difficult to explain factorially and are indeed surprising. It might be that Pb.C 281 and Pb.C 518 are carrying some factor or factors which prevented the expression of one of the factors of NP 790.

Hynes *et al.* (1925), working with race 21, reported resistance to be governed by a single dominant gene in the double cross (Marquis × Iumillo) (S) × (Marquis × Kanred) (I). Ayad (1952), in the crosses Hindi 62(S) × Hindi Immune (R) and Gaza 139(R) × Hindi 62(S) and Athwal (1953), in the cross Federation (S) × Gabo(R), also reported similar results.

In a resistance-breeding programme, it is essential to know the nature of the genes present in the different genetic stocks under use. It is also essential to find out whether the same gene or genes, present in a particular variety and governing the reaction to a particular race, also govern the reaction to other races. If this information is available, it would very much facilitate the breeding work. A number of instances are known where a single gene persent in a variety was found to govern the reaction to a number of other races. In India, this information is lacking and hence needs investigation. From a perusal of the data of the cross E 871 × NP 718 for both races 15 and

21, it may be observed that a single dominant gene of E 871 is governing the reaction to each of the races. It may be that the same gene of E 871 is responsible for controlling the resistance to both these races. However, this needs checking up by testing the $F_3$ and $F_4$ of this cross against both the races.

## SUMMARY

The results of the studies undertaken to find out the mode of inheritance of seedling reaction to races 15 and 21 of black rust in certain intervarietal crosses of the common bread wheat have been reported.

Both Timstein × 2086 Sel. 1495A-1-31-2-1 and Rionegro were found to carry one dominant factor each for resistance to race 15. The resistance of E 952 (Rionegro) was inhibited by another factor carried by the same wheat.

The seedling reaction to race 21 was governed by a single dominant gene of Timstein × 2086 Sel. 1495A-1-31-2-1 and a single recessive factor of E 952. Kenya 184.P.2.A.1.F. was found to carry two duplicate dominant genes for controlling the seedling resistance to the same race. NP 790 gave a 3R:1S ratio in some crosses and 15R:1S ratio in others when tested against race 21.

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# COBALT STATUS OF FORAGE PLANTS GROWN ON *GORADU* SOIL*

K. G. REDDY and B. V. MEHTA

*Institute of Agriculture, Anand*

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The cobalt content of herbage has assumed importance in recent years because of the relationship between the cobalt content of herbage and animal nutrition. According to Underwood (1956), the trace element composition of herbage can be an important consideration in determining the incidence of nutritional diseases in animals which are related to deficiencies or excesses of trace elements. Nutritional disorders of animals fed on plants of low cobalt contents are reported from many parts of the world (Beeson, 1950). Various local names are given to these maladies such as "Bush-sickness" in New Zealand, "Coast disease" in South Australia, "Salt-sickness" in Florida, "Pining" in Britain, etc.

It has been shown by Reddy (1960) that *goradu* soil contains 0·15 to 0·66 ppm. available cobalt, as determined by extraction with 2·5 per cent acetic acid adjusted to pH 2·5—a method that has given good correlation with the plant uptake of cobalt. Stewart (1953), while investigating cobalt deficiency in pastures of Great Britain, stated that in mineral soils, less than 0·25 ppm. cobalt soluble in acetic acid of pH 2·5 indicates deficiency and more than 0·3 ppm. cobalt indicates sufficiency. Thus there is a possibility of deficiency of cobalt for the normal health of animals. But Mitchell (1958) has stated that "in view of the variation in the uptake of most trace elements with different species and varieties of plants and effects of soil factors such as pH and organic matter content, it is doubtful whether any method of chemical extraction can ever be used as more than an indication of probable trace element behaviour."

It is, thus, obvious that the composition of herbage can be an important consideration in determining the availability of a nutrient. Such a determination can also throw light on the incidence of nutritional diseases in animals which are related to deficiencies or excesses of trace elements. The concentration of trace elements in plants is dependent upon the plant species, nature of soil, element, stage of growth, application of fertilizers and the use of soil amendments, etc. But, basically, the mineral composition of the plant is a reflection of the species and the soil conditions under which it is grown. The purpose of this study was to assess the cobalt status of forage plants growing on *goradu* soil in different locations of Kaira district (Gujarat), known for good milch cattle, in order to know whether the fodders are capable of supplying enough cobalt for the normal health of animals.

## MATERIAL AND METHODS

Twenty-seven different fodder crops grown at Anand and six common fodders, each grown at seven different locations (Table II), having *goradu* soil, were cut at the

* Part of the M. Sc. thesis submitted by the senior author to S. V. University, Anand.

mature stage, leaving about a two-inch portion of the plant from the surface of the soil. The samples were dried at 70° C and colorimetrically analysed for cobalt by the 2-nitroso-l-naphthol method (Andrews *et al.*, 1958), after digesting the samples by Sandell's method (Sandell, 1950).

## RESULTS AND DISCUSSION

The results of forage analysis are given in Tables I and II.

TABLE I. COBALT CONTENT OF GRASSES AND STRAWS OF CEREALS GROWN ON *GORADU* SOIL, ANAND
(Oven-dry basis)

| Common name | Botanical name | Cobalt in ppm. |
|---|---|---|
| Spear grass | *Andropogan contortus* Linn. | 0·55 |
| *Survala* | *Andropogan isachaemum* | 0·33 |
| *Anjan* grass | *Cenchrus ciliaris* | 0·35 |
| Zinzvo | *Dichanthium annulatum* Stapf. | 0·15 |
| Marvel selection | *Dichanthium caricosum* | |
| Group I | | 0·35 |
| Group II | | 0·48 |
| Group III | | 0·38 |
| Group IV | | 0·34 |
| Group V | | 0·18 |
| Veldt love | *Eragrostis superba* | 0·33 |
| Green panic | .. | 0·38 |
| .. | *Panicum laevifolium* | 0·43 |
| .. | *Panicum* sp. | 0·45 |
| Para grass | *Panicum muticum* | 0·35 |
| Elephant grass | *Pennisetum purpureum* | 0·48 |
| *Dandi* | *Pennisetum ciliaris* | 0·38 |
| Napier grass | *Pennisetum polystachyon* | 0·34 |
| *Dhaman* | *Pennisetum cenchroides* | 0·25 |
| Blue Panic | *Panicum antidotale* Rets. | 0·65 |
| Sudan grass | *Sorghum sudanease* | 0·37 |
| Guinea grass | *Panicum maximum* Jacq. | 0·19 |
| Natal grass | *Tricholaena rosea* | 0·23 |
| Mathyanya | *Chorie incompleta* Roth. | 0·36 |
| Rhodes grass | *Chloris gayana* Kunth | 0·38 |
| Maize (straw) | *Zea mays* L. | 1·10 |
| Oat ( ,, ) | *Avena sativa* L. | 0·54 |
| Wheat ( ,, ) | *Triticum sativum* Law | 0·27 |

TABLE II. COBALT CONTENT OF COMMON FODDERS FROM DIFFERENT PLACES IN KAIRA DISTRICT

| Common name | Botanical name | Cobalt content in parts per million | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ajarpura | Anand (Institute) | Ban-dhani | Bodal | Davol | Samar-kha | Sande-sar | Average |
| Alfalfa | *Medicago sativa* L. | .. | 0·50 | .. | 0·20 | .. | 0·26 | 0·40 | 0·34 |
| *Bajri* | *Pennisetum typhoideum* Rich. | 0·23 | 0·26 | 0·33 | 0·32 | 0·33 | 0·23 | 0·20 | 0·27 |
| *Bavto* | *Eleusine coracana* Linn. | 0·50 | 0·80 | 1·20 | 0·74 | 0·80 | 0·70 | 0·28 | 0·72 |
| *Kodra* | *Paspalum scrobiculatum* Linn. | 0·88 | 0·90 | 0·67 | 0·58 | 0·82 | 1·03 | 0·62 | 0·79 |
| Paddy | *Oryza sativa* L. | 0·70 | 0·91 | 0·56 | 0·50 | 1·40 | 0·61 | 0·68 | 0·77 |
| *Sundhia jowar* | *Sorghum vulgare* | 0·18 | 0·31 | 0·25 | 0·15 | 0·19 | 0·34 | 0·19 | 0·23 |
| | Average | 0·50 | 0·61 | 0·60 | 0·42 | 0·71 | 0·53 | 0·39 | |

Out of the grasses and straws of cereals grown on *goradu* soil at Anand, the latter appear to contain more cobalt than the former. Among the grasses, *Dichanthium annulatum* Stapf. contains the lowest (0·15 ppm.) and Blue Panic the highest (0·65 ppm.) amount of cobalt. Out of the marvel selection groups, groups II and V contain 0·48 (highest) and 0·18 (lowest) ppm. of cobalt, respectively. This shows that cereal straws have more cobalt-absorbing capacity than grasses.

From the results of analysis of different common fodders from different villages (Table II), it is apparent that the *kodra*, paddy and *bavto* straws are richer in cobalt content than alfalfa, *bajri* and *sundhia jowar*. The former group contains more than twice the amount present in the latter. *Jowar* contains the minimum amount (0·15 ppm.) of cobalt. It is also apparent that the cobalt content varies within the species from location and with different species at the same place. It is seen that even within the species, there is variation of more than 200 per cent even on *goradu* soil only, as will be clear from the ranges given below:

| Species | Cobalt content in ppm. | |
|---|---|---|
| | Range | Average |
| Alfalfa | 0·20–0·50 | 0·34 |
| *Bajri* | 0·20–0·33 | 0·27 |
| *Bavto* | 0·28–1·20 | 0·72 |
| *Kodra* | 0·58–1·03 | 0·79 |
| Paddy | 0·50–1·40 | 0·77 |
| *Sundhia jowar* | 0·15–0·34 | 0·23 |

Fodder samples from the Davol area contain, on an average, 0·71 ppm. of cobalt, which is the highest among the seven villages. Anand and Bandhani are next with an average of 0·61 and 0·60 ppm., respectively. These are followed by Samarkha and Ajarpura with an average of 0·53 and 0·50 ppm., respectively. *Bodal* fodders have the minimum cobalt content with an average of 0·42 ppm.

Iyer (1958) reported that the cobalt content of grasses of Western India varied from 0·2 to 1·0 ppm. with an average of 0·6 ppm. The legumes contained slightly higher amounts of cobalt varying from 0·4 to 1·6 ppm. with an average of 0·8 ppm. Bowstead and Sockville (1939) found that non-leguminous hays generally contained low cobalt, whereas alfalfa hay grown on similar soil contained relatively large amounts of cobalt. Some other investigators also reported that legumes contained more cobalt than grasses (Reddy, 1960; Stewart, 1953). Bear (1954) reported that the cobalt content of legumes varied from 0·12 to 0·17 ppm., while that of grasses varied from 0·05 to 0·20 ppm. when grown under identical conditions.

According to the two comprehensive reviews of literature on cobalt nutrition of plants and animals (Young, 1948), the minimum levels of cobalt content in forages for the normal health of animals have been established. McNaught's (1938) estimate was 0·17 ppm. According to Hipkirk and Grimmett (1938), sheep suffer from cobalt deficiency when their feed contains less than 0·04 ppm. Marston's (1952) estimate was 0·08 to 0·10 ppm. Stewart (1951) stated that the cobalt content of Scottish pasture on which lambs pine ranges from 0·03 to 0·10 ppm., while Andrews *et al.* (1958) rate this at 0·11 ppm. cobalt for lambs.

It is clearly seen from the results of analysis of different species of plants from different places that these forage crops contain cobalt much above the minimum levels suggested by various workers. It can thus be said that at present there is no likelihood of deficiency of cobalt among the animals eating fodders of these areas.


## SUMMARY

In order to assess the cobalt status of fodders grown in *goradu* soil, a study has been made of the cobalt contents of fodder samples of different species grown on this soil. Twenty-four grasses and three straws grown at Anand and six common fodders grown at Ajarpura, Anand, Bandhani, Bodal, Davol, Sandesar and Samarkha in Kaira district, were collected and analysed for their cobalt content. The average cobalt contents of grasses and cereal straws grown on *goradu* soil at Anand are 0·36 and 0·64 ppm. respectively. The cobalt content of fodders from Davol is the highest (average 0·71 ppm.) among the samples of seven villages. Further, there is considerable variation in the cobalt content of the same fodders grown on *goradu* soil at different sites. In spite of these variations, there is no likelihood of cobalt deficiency in grazing animals in any of these places under the present soil conditions.



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# EFFECT OF FERTILIZERS ON THE NUTRITIVE VALUE OF RICE GRAIN

M. N. BASAK, S. B. CHAUDHURI and ROMA BHATTACHARYA

*State Agricultural Research Institute, Calcutta*

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Although rice is the staple food of more than half the human race, typical diets of rice-eating countries are usually susceptible to protein deficiency (FAO, 1954 a, b). This is partly due to the inadequate supplementation of animal proteins resulting from poverty of the feeding population and partly due to the low protein value of rice. This low protein value (=protein content × biological value × digestibility coefficient) is attributable to the low protein content, because the biological value and digestibility coefficient of rice proteins are the highest among cereal proteins (FAO, 1954b; Basu and Basak, 1937 and 1939; Basu, Basak and De, 1941). Plant breeding and selection techniques have not been seriously attempted at or succeeded in improving the protein content of the rice grain. Fertilization of the growing crop for raising the overall nutritional level is a possibility worth exploration.

Literature on the subject seems scanty (Jacks and Milne, 1954; FAO, 1954b). Veiasco (1940) found no significant correlation between the soil N and protein content of the grain. Sturgis *et al.* (1952) observed that fertilizers increased the rice yield but gave no significant increase in the protein N. Application of N, P and K had no effect on the protein, niacin, biotin or pantothenic acid content of rice (Kik, 1951). Ishizuka and Tanaka (1952a, b) found that increasing the P application caused an increase and that of K a decrease in the protein content of the grain. Working with culture solutions, these authors (1950) found a marked interrelationship to exist between the N concentration of the solution, the yield and the N content of the plant. With a concentration greater than 60 ppm. of N, the yield decreased but the N content of the plant and grain increased, the increase in the grain protein-N being attributed to the alkali-soluble protein oryzenin.

In the course of agronomic investigations undertaken for boosting rice yield through manuring and fertilization (Basak and Klemme, 1959; Basak, Bhattacharjee and Sen, 1960), systematic analytical studies were made of the proximate values of grain samples obtained from several rice varieties grown in different soil-climatic zones of West Bengal under different manurial and fertilizer patterns. The effects of manuring and fertilization of rice plant on the nutritional composition of its grain have been described in the present paper.

## MATERIAL AND METHODS

Two parallel sets of trials were conducted in farmers' fields in different soil climatic zones of West Bengal during the 1958 paddy season. N was applied at the rate of 30 lb. per acre, as ammonium sulphate in one set and compost in another.

Superphosphate at the rate of 20 lb. $P_2O_5$ per acre was superimposed on N, and muriate of potash at the rate of 20 lb. $K_2O$ per acre on the NP treatment in both the sets with respective checks. The treatments were applied during puddling of soils before transplantation of seedlings. Crop yields obtained by different treatments have been reported earlier (Basak *et al.*, 1960). Representative samples of grain collected from the produce of each treatment were dried, husked and finely powdered. A composite sample was taken for analysis for the total nitrogen, phosphoric acid and calcium. The total nitrogen was estimated by Kjeldahl's method and phosphoric acid and calcium by the methods described by Piper (1950). Data on the composition of the grain are given in Table I.

TABLE I. COMPOSITION OF HUSKED RICE UNDER DIFFERENT MANURIAL* TREATMENTS (calculated on oven-dry basis)

| Soil type and Centre | Variety | Treatments: N compost | | | | Treatments: N Ammonium sulphate | | | | Analysis of variance |
|---|---|---|---|---|---|---|---|---|---|---|
| | | O | N | NP | NPK | O | N | NP | NPK | |
| *Gangetic alluvium* | | Per cent nitrogen | | | | | | | | |
| Santipur | Kele-aman | 1·151 | 1·264 | 1·247 | 1·247 | 1·247 | 1·391 | 1·374 | 1·247 | 'F' test among treatments not significant at 5% level |
| Ranaghat | Nagra | 1·231 | 1·264 | 1·327 | 1·374 | 1·096 | 1·040 | 1·040 | 1·199 | |
| Baruipur | Dadkhani | 1·008 | 1·092 | 1·118 | 1·040 | 1·024 | 1·092 | 1·199 | 1·072 | |
| Budge Budge | Patnai 23 | 1·087 | 1·118 | 1·118 | 1·278 | 1·135 | 1·118 | 1·118 | 1·168 | |
| Katwa | Kalma | 1·085 | 1·021 | 1·054 | 1·004 | 1·068 | 1·150 | 1·037 | 1·244 | |
| Kalna | Kalma | 1·196 | 1·150 | 1·164 | 1·196 | 1·150 | 1·164 | 1·237 | 1·237 | |
| Mean | | 1·126 | 1·151 | 1·171 | 1·190 | 1·120 | 1·159 | 1·167 | 1·194 | |
| *Lateritic* | | | | | | | | | | |
| Suri | Sindurmukhi | 0·976 | 0·976 | 1·028 | 1·055 | 1·072 | 1·076 | 1·108 | 1·076 | 'F' test among treatments not significant at 5% level; 'T' test between soil types significant at 1% level |
| Bankura | Bhasamanik | 1·092 | 1·135 | 1·118 | 1·092 | 1·072 | 1·151 | 1·072 | 1·183 | |
| Midnapore | Panlai aman | 1·199 | 1·072 | 1·168 | 1·151 | 1·231 | 1·183 | 1·135 | 1·151 | |
| Vishnupur | Dahar Nagra | 1·151 | 1·151 | 1·118 | 1·135 | 1·135 | 1·072 | 1·168 | 1·151 | |
| Kandi | Bhasamanik | 1·117 | 1·054 | 1·021 | 1·054 | 1·068 | 0·990 | 1·181 | 1·133 | |
| Mean | | 1·107 | 1·078 | 1·091 | 1·097 | 1·116 | 1·094 | 1·133 | 1·139 | |
| Grand mean | | 1·117 | 1·118 | 1·135 | 1·148 | 1·118 | 1·130 | 1·152 | 1·169 | |
| *Gangetic alluvium* | | Per cent phosphorus ($P_2O_5$) | | | | | | | | |
| Santipur | Kele-aman | 0·760 | 0·780 | 0·745 | 0·766 | 0·780 | 0·808 | 0·787 | 0·773 | 'F' test among treatments not significant at 5% level |
| Ranaghat | Nagra | 0·739 | 0·787 | 0·780 | 0·780 | 0·739 | 0·667 | 0·725 | 0·773 | |
| Baruipur | Dadkhani | 0·667 | 0·647 | 0·660 | 0·719 | 0·667 | 0·667 | 0·766 | 0·673 | |

* N @ 30 lb. per acre: P @ 20 lb. $P_2O_5$ per acre as superphosphate: K @ 20 lb. $K_2O$ per acre as muriate of potash

TABLE I.—(*Contd.*)

| Soil type and Centre | Variety | Treatments: N compost | | | | Treatments: N Ammonium sulphate | | | | Analysis of variance |
|---|---|---|---|---|---|---|---|---|---|---|
| | | O | N | NP | NPK | O | N | NP | NPK | |
| Budge Budge | Patnai 23 | 0·667 | 0·647 | 0·673 | 0·719 | 0·680 | 0·667 | 0·712 | 0·673 | 'F' test among treatments not significant at 5% level |
| Katwa | Kalma | 0·640 | 0·538 | 0·667 | 0·673 | 0·673 | 0·673 | 0·632 | 0·681 | |
| Kalna | Kalma | 0·632 | 0·680 | 0·632 | 0·667 | 0·623 | 0·667 | 0·680 | 0·653 | |
| Mean | | 0·684 | 0·680 | 0·693 | 0·721 | 0·694 | 0·691 | 0·717 | 0·704 | |
| *Lateritic* | | | | | | | | | | |
| Suri | Sindurmukhi | 0·704 | 0·766 | 0·697 | 0·691 | 0·623 | 0·650 | 0·602 | 0·602 | 'F' test among treatments not significant at 5% level; 'T' test between soil types significant at 1% level |
| Bankura | Bhasamanik | 0·660 | 0·647 | 0·647 | 0·719 | 0·599 | 0·673 | 0·660 | 0·647 | |
| Midnapore | Panlai aman | 0·773 | 0·706 | 0·684 | 0·745 | 0·673 | 0·680 | 0·719 | 0·739 | |
| Vishnupur | Dahar Nagra | 0·691 | 0·671 | 0·629 | 0·711 | 0·680 | 0·688 | 0·650 | 0·667 | |
| Kandi | Bhasamanik | 0·623 | 0·629 | 0·650 | 0·650 | 0·599 | 0·640 | 0·667 | 0·684 | |
| Mean | | 0·690 | 0·684 | 0·661 | 0·703 | 0·635 | 0·666 | 0·640 | 0·668 | |
| Grand mean | | 0·687 | 0·682 | 0·678 | 0·713 | 0·667 | 0·680 | 0·682 | 0·688 | |
| *Gangetic alluvium* | | Per cent calcium (CaO) | | | | | | | | |
| Santipur | Kele-aman | 0·330 | 0·306 | 0·306 | 0·306 | 0·306 | 0·402 | 0·380 | 0·306 | 'F' test among treatments not significant at 5% level |
| Ranaghat | Nagra | 0·198 | 0·177 | 0·142 | 0·142 | 0·129 | 0·118 | 0·129 | 0·118 | |
| Budge Budge | Patnai 23 | 0·212 | 0·201 | 0·157 | 0·129 | 0·100 | 0·157 | 0·118 | 0·129 | |
| Katwa | Kalma | 0·188 | 0·142 | 0·142 | 0·188 | 0·118 | 0·142 | 0·142 | 0·118 | |
| Kalna | Kalma | 0·165 | 0·165 | 0·165 | 0·188 | 0·142 | 0·188 | 0·142 | 0·236 | |
| Mean | | 0·219 | 0·198 | 0·182 | 0·191 | 0·159 | 0·201 | 0·182 | 0·181 | |
| *Lateritic* | | | | | | | | | | |
| Suri | Sindurmukhi | 0·283 | 0·306 | 0·306 | 0·283 | 0·330 | 0·283 | 0·306 | 0·283 | 'F' test among treatments not significant at 5% level; 'T' test between soil types significant at 5% level |
| Bankura | Bhasamanik | 0·142 | 0·157 | 0·129 | 0·129 | 0·129 | 0·142 | 0·142 | 0·165 | |
| Midnapore | Panlai aman | 0·129 | 0·142 | 0·106 | 0·106 | 0·142 | 0·118 | 0·118 | 0·106 | |
| Vishnupur | Dahar Nagra | 0·118 | 0·106 | 0·106 | 0·106 | 0·129 | 0·142 | 0·118 | 0·118 | |
| Kandi | Bhasamanik | 0·118 | 0·165 | 0·118 | 0·165 | 0·142 | 0·118 | 0·142 | 0·142 | |
| Mean | | 0·158 | 0·175 | 0·153 | 0·158 | 0·174 | 0·161 | 0·165 | 0·163 | |
| Grand mean | | 0·188 | 0·186 | 0·167 | 0·174 | 0·166 | 0·181 | 0·173 | 0·172 | |

A randomized replicated experiment was conducted with a departmental selection (var. Bhasamanik) at the State Experimental Farm, Chinsurah. Ammonium

sulphate, urea and sodium nitrate were applied at the rate of 20 lb. N per acre as a topdressing and foliar spray. The treatments were applied in three equal splits at different stages of crop-growth indicated in Table II. A composite solution of 11 'trace' elements* constituted another treatment of foliar application in three equal splits at the corresponding stages of crop-growth. Grain samples were similarly collected from each replicated treatment, dried, husked, ground and analysed. Data are given in Table II.

Another series of trials were undertaken in farmers' fields on local rice varieties with three doses of nitrogen (30 lb. N, 60 lb. N and 90 lb. N per acre) against check. N was supplied in the mixed form of organic (compost) and inorganic (ammonium sulphate) in the ratio of 2:1. Compost was applied during puddling and ammonium sulphate was topdressed in two equal splits at the tillering and pre-flowering stages. Data on the composition of grain are given in Table III.

## RESULTS

*Influence of N fertilization on the protein content of grain*

Application of 30 lb. N per acre, in the form of compost or ammonium sulphate, during puddling of soils prior to transplantation of seedlings, did not show any effect on the nitrogen content of the grain (Table I), although the same treatments increased the grain yield by about 45 per cent over checks (Basak, Bhattacharjee and Sen, 1960). Supplementation of phosphate, potash and calcium with nitrogen at puddling time also did not show any influence on the nitrogen content.

But topdressing and foliar application of soluble nitrogenous fertilizers significantly increased the content of grain protein-N (Table II). The value of ammonium sulphate > urea > sodium nitrate, in this respect. Topdressing and foliar application had almost equal merits. The protein-enriching value of applied N apparently depended on the precise time of its application in relation to the physiological phase of crop-life, because identical N treatments applied on one set of dates (September 1, September 15 and October 1 in 1958) caused a significant increase in the protein-N content while those applied on an earlier set of dates (August 15, September 1 and September 15 in 1959) did none (Table II).

In the trial series with progressively higher doses of N (30 lb., 60 lb. and 90 lb. per acre), two-third N being applied as compost during puddling of soils and one-third N as ammonium sulphate in two equal splits at the tillering and pre-flowering stages, the grain protein-N showed a progressively higher trend with the mounting dose of applied N. At 90 lb. N per acre, the value of protein-N was significantly superior to that of unmanured check (Table III). However, the increase in protein-N was not commensurate with the level of applied N, as judged from the results given in Table II. It would imply that the organic N applied at puddling exercised no influence on the protein-N content of the grain, thus confirming the earlier observations (Table I). Excessive rainfall during the 1959 cropping season perhaps had a share in

* Sodium molybdate 144 g., copper sulphate 120 g., manganese sulphate 120 g., boric acid 72 g., zinc sulphate 72 g., nickel sulphate 48 g., cobalt chloride 48 g., titanium chloride 24 g., vanadium chloride 24 g., chromium sulphate 24 g. and sodium tungstate 24 g. per acre.

TABLE II. COMPOSITION OF HUSKED RICE UNDER INFLUENCE OF SOLUBLE N* FERTILIZATION
(calculated on oven-dry basis)
EXPERIMENTAL STATION, CHINSURAH: VAR. BHASAMANIK

| Treatments | | Nitrogen per cent | | | | Phosphorus ($P_2O_5$) per cent | | | | Calcium (CaO) per cent | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Material | Method | A | B | C | D | A | B | C | D | A | B | C | D |
| Year 1958 | | | | | | | | | | | | | |
| Control | .. | 0·989 | 1·033 | 1·033 | 1·134 | 0·578 | 0·593 | 0·521 | 0·599 | 0·156 | 0·171 | 0·220 | 0·227 |
| Ammonium sulphate | Topdressing | 1·427 | 1·297 | 1·540 | 1·371 | 0·644 | 0·682 | 0·526 | 0·644 | 0·227 | 0·213 | 0·237 | 0·227 |
| ,, | Spraying | 1·401 | 1·384 | 1·344 | 1·271 | 0·692 | 0·576 | 0·730 | 0·700 | 0·298 | 0·160 | 0·174 | 0·145 |
| Urea | Topdressing | 1·362 | 1·324 | 1·486 | 1·312 | 0·627 | 0·591 | 0·692 | 0·637 | 0·256 | 0·265 | 0·145 | 0·188 |
| ,, | Spraying | 1·351 | 1·168 | 1·284 | 1·167 | 0·602 | 0·567 | 0·599 | 0·678 | 0·213 | 0·213 | 0·241 | 0·204 |
| Sodium nitrate | Topdressing | 1·115 | 1·092 | 1·242 | 1·220 | 0·618 | 0·600 | 0·557 | 0·496 | 0·164 | 0·160 | 0·145 | 0·220 |
| ,, | Spraying | 1·312 | 1·134 | 1·176 | 1·184 | 0·559 | 0·631 | 0·642 | 0·530 | 0·131 | 0·153 | 0·131 | 0·175 |
| Trace elements | ,, | 0·994 | 1·162 | 1·167 | 1·050 | 0·635 | 0·562 | 0·622 | 0·612 | 0·174 | 0·196 | 0·160 | 0·167 |
| Analysis of variance | | 'F' test significant at 1% level<br>S.E.m = $\pm 0 \cdot 037$<br>C.D. = $\pm 0 \cdot 150$ at 1% level<br>C.D. = $\pm 0 \cdot 110$ at 5% level | | | | 'F' test not significant at 5% level | | | | 'F' test not significant at 5% level | | | |
| Year 1959 | | | | | | | | | | | | | |
| Control | .. | 0·960 | 1·061 | 1·036 | 1·061 | 0·566 | 0·566 | 0·610 | 0·610 | 0·218 | 0·189 | 0·189 | 0·203 |
| Ammonium sulphate | Topdressing | 1·364 | 1·238 | 0·907 | 1·162 | 0·666 | 0·588 | 0·605 | 0·644 | 0·218 | 0·203 | 0·203 | 0·203 |
| ,, | Spraying | 1·212 | 1·112 | 1·137 | 1·137 | 0·678 | 0·538 | 0·594 | 0·644 | 0·174 | 0·218 | 0·160 | 0·203 |
| Urea | Topdressing | 1·212 | 1·137 | 1·238 | 1·137 | 0·666 | 0·605 | 0·672 | 0·633 | 0·174 | 0·174 | 0·160 | 0·160 |
| ,, | Spraying | 1·384 | 1·134 | 1·235 | 1·210 | 0·554 | 0·554 | 0·633 | 0·666 | 0·183 | 0·160 | 0·145 | 0·131 |
| Sodium nitrate | Topdressing | 1·134 | 1·184 | 1·134 | 1·210 | 0·515 | 0·610 | 0·588 | 0·655 | 0·174 | 0·189 | 0·174 | 0·145 |
| ,, | Spraying | 1·159 | 1·134 | 1·159 | 1·134 | 0·552 | 0·610 | 0·706 | 0·622 | 0·116 | 0·145 | 0·131 | 0·145 |
| Trace elements | ,, | 1·058 | 1·019 | 1·084 | 1·058 | 0·577 | 0·627 | 0·638 | 0·627 | 0·145 | 0·232 | 0·160 | 0·160 |
| Analysis of variance | | 'F' test not significant at 5% level | | | | 'F' test not significant at 5% level | | | | 'F' test not significant at 5% level | | | |

*N @ 20 lb. per acre in three equal splits: dates of application—1958: September 1, September 15 and October 1
1959: August 15, September 1 and September 15

A, B, C and D replications

the reduction of the potential benefit of topdressed N as a result of heavier leaching from the soil.

*Influence of P, K and Ca fertilization on the protein, P and Ca contents of grain*

Application of water-soluble phosphate at the rate of 20 lb. $P_2O_5$ per acre in conjunction with N and NK fertilizers did not show any significant change in the P content of the grain (Table I). Organic phosphorus added to the soil as compost, equivalent to about 30 lb. $P_2O_5$ per acre, or an additional dose of soluble phosphate supplemented therewith, also did not reflect any change in the grain P content (Table I).

When soluble-N-fertilization caused a significant increase in the content of grain protein-N, the P content showed a correspondingly higher trend over unfertilized checks although no phosphatic fertilization was resorted to (Table II). The trend was not, however, significant and was absent in cases where N-fertilization did not reflect any change in the grain protein-N. Results given in Table III also confirmed these observations. The values of phytin P were not consistent enough to give any clue.

Application of potassium (as muriate of potash at the rate of 20 lb. $K_2O$ per acre) in conjunction with NP fertilizers, and of calcium (as superphosphate at the rate of 30 lb. CaO per acre) with NP and NPK fertilizers, did not produce any change on the protein-N, calcium and phosphorus contents of the grain (Table I). Foliar application of ' trace ' elements had also no effect on any of these nutritive components of the grain (Table II).

*Influence of soil type on the nutritive value of grain*

The grain produced in the Gangetic alluvium soils was found to be significantly superior to that grown in lateritic soils in the contents of protein-N, phosphorus and calcium (Table I). The grain produced in alluvium soil was richer in protein-N by 4·8 per cent, in phosphorus ($P_2O_5$) by 4·5 per cent and in calcium (CaO) by 15·9 per cent over the grain produced in lateritic soil. But in years of excessive rainfall, such differences in the nutritional composition of the grain due to differences in soil type and fertility status were not detectable (Table III).

*Varietal difference and nutritive quality of grain*

Of the several rice varieties grown, three, namely, Bhasamanik, Patnai 23 and Kalma of comparable grain size and life-period were statistically tested for comparing the nutritive quality of their grains (Tables I and III). An analysis of variance in N, $P_2O_5$ and CaO contents of the grains obtained from check plots did not indicate any significant differences among the varieties in the contents of these nutritional elements.

*Correlation between the nutritive contents of grain*

Correlation co-efficients were worked out between the three pairs of nutrients

TABLE III. COMPOSITION OF HUSKED RICE UNDER MIXED FORM OF N FERTILIZATION
(calculated on oven-dry basis)

| Soil type and centre | Variety | Per cent N under treatments | | | | Per cent $P_2O_5$ under treatments | | | | Per cent CaO under treatments | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0N | 30N | 60N | 90N | 0N | 30N | 60N | 90N | 0N | 30N | 60N | 90N |
| *Gangetic alluvium* | | | | | | | | | | | | | |
| Noapara | Bhasamanik | 1·106 | 1·106 | 1·098 | 1·098 | 0·638 | 0·683 | 0·650 | 0·666 | 0·145 | 0·160 | 0·116 | 0·145 |
| Baidyabati | Patnai 23 | 1·313 | 1·313 | 1·288 | 1·313 | 0·700 | 0·706 | 0·734 | 0·689 | 0·160 | 0·232 | 0·160 | 0·145 |
| Kalna | Bhasamanik | 1·176 | 1·229 | 1·128 | 1·229 | 0·706 | 0·694 | 0·667 | 0·678 | 0·131 | 0·131 | 0·145 | 0·145 |
| Behala | Jamainaru | 1·288 | 1·288 | 1·414 | 1·364 | 0·605 | 0·711 | 0·734 | 0·762 | 0·116 | 0·116 | 0·145 | 0·131 |
| Rishra | Patnai 23 | 1·464 | 1·464 | 1·411 | 1·624 | 0·717 | 0·706 | 0·694 | 0·762 | 0·131 | 0·116 | 0·116 | 0·145 |
| Mean | | 1·269 | 1·280 | 1·268 | 1·326 | 0·673 | 0·700 | 0·696 | 0·711 | 0·137 | 0·151 | 0·136 | 0·142 |
| *Lateritic and red soils* | | | | | | | | | | | | | |
| Bankura | Patnai 23 | 1·128 | 1·176 | 1·098 | 1·238 | 0·706 | 0·778 | 0·711 | 0·773 | 0·116 | 0·116 | 0·116 | 0·131 |
| Bankura | Kalamkati | 1·137 | 1·212 | 1·162 | 1·212 | 0·711 | 0·683 | 0·689 | 0·683 | 0·160 | 0·160 | 0·116 | 0·131 |
| Maldah | Jhulan | 1·148 | 1·176 | 1·229 | 1·434 | 0·722 | 0·750 | 0·689 | 0·750 | 0·131 | 0·145 | 0·145 | 0·160 |
| Raghunathpur | Patani 108 | 0·960 | 1·011 | 1·112 | 1·112 | 0·661 | 0·650 | 0·683 | 0·694 | 0·145 | 0·131 | 0·131 | 0·102 |
| Kandi | Bhasamanik | 1·489 | 1·313 | 1·540 | 1·565 | 0·689 | 0·694 | 0·706 | 0·689 | 0·247 | 0·189 | 0·160 | 0·160 |
| Mean | | 1·172 | 1·178 | 1·228 | 1·312 | 0·698 | 0·711 | 0·698 | 0·718 | 0·160 | 0·148 | 0·134 | 0·137 |
| Grand mean | | 1·221 | 1·229 | 1·248 | 1·319 | 0·685 | 0·705 | 0·696 | 0·715 | 0·148 | 0·150 | 0·135 | 0·139 |
| Analysis of variance | | 'F' test significant at 1% level<br>S.E.m=±0·019<br>C.D.=±0·075 at 1% level<br>C.D.=±0·055 at 5% level | | | | 'F' test not significant at 5% level | | | | 'F' test not significant at 5% level | | | |
| 'T' test between soil types | | Not significant at 5% level | | | | Not significant at 5% level | | | | Not significant at 5% level | | | |

in the grain (Tables I, II and III) and their values are indicated below.

| Nutrients | Correlation co-efficient (r) | |
|---|---|---|
| Nitrogen and phosphorus ($P_2O_5$) | +0·1232 | * |
| Nitrogen and calcium (CaO) | +0·3789 | * |
| Phosphorus ($P_2O_5$) and calcium (CaO) | −0·1909 | * |

* Not significant at 5% level

## DISCUSSION

Nitrogenous manuring and fertilization have given substantial increases in the grain production. Equal amounts of nitrogen of compost and ammonium sulphate or a combination of the two gave identical yield-responses (Basak, 1956; Basak, Dutt and Nag, 1957). Ammonium sulphate applied at puddling time or topdressed at the tillering and pre-flowering stages, in conjunction with a basal dose of compost, also gave a similar magnitude of yield-responses (Basak and Klemme, 1959).

Compost and ammonium sulphate applied at puddling time at the rate of 30 lb. N per acre increased the grain yield by about 45 per cent over control (Basak, Bhattacharjee and Sen, 1960). The same treatments, however, did not show any effect on the protein content of the grain (Table I). Supplementation with phosphate and potash also had no influence on the content of grain protein. But application of soluble nitrogen (ammonium sulphate and urea) as topdressing or foliar spray about three weeks ahead of the heading time significantly increased the protein content of the grain, while the same treatments applied earlier did not (Table II). Thus, the form of nitrogen and the time of its application in relation to a particular physiological phase of the crop-life corresponding to the early reproductive stage, seemed to be crucially important in influencing the protein content of the grain. Evidence of rapid absorption of N from late-dressed ammonium sulphate and its maximum translocation to and concentration in the reproductive parts of the plant was obtained by Ozaki and Mitsui (1950). They found that most of the $N^{15}$ supplied before heading was utilized by the most active parts of the plant in their early physiological drift. At harvest time, 38 per cent of the labelled N was found in the ears. Mitsui (1955) also explained that the higher percentage of recovery of applied nitrogen (60-70 per cent) in late dressing (pre-flowering) as compared to basal dressing (30-40 per cent) was due to the extremely rapid absorption of nitrogen by the fully developed root system and the minimized denitrification process on prolonged flooding after transplantation.

Application of organic phosphorus or water-soluble phosphate or a combination of the two showed no influence on either the phosphorus or protein content of the grain. Because the reduction of iron and aluminium phosphates, which usually constituted about 50-66 per cent of the total soil phosphorus, under anaerobic conditions due to prolonged waterlogging, could be expected to release enough of water-soluble phosphate ions to meet the phosphorus requirement of the growing crop (Basak *et al.*, 1960).

The Gangetic alluvium soil appeared to produce grain of superior nutritive quality than lateritic soil. Superiority of the former soil type over the latter was

apparently due to its superior nutrient status (Basak and Klemme, 1959). But applied nutrients alone did not induce any improvement in grain quality in less fertile lateritic soil. In view of its lower moisture-retentive capacity and of general shortage of precipitation during the reproductive phase of the rainfed crop (Basak, 1957; Basak *et al.*, 1960), lateritic soil was far more susceptible to moisture deficiency than the Gangetic alluvium. Deficiency of moisture could be as important in the release of nutrients from the soil and utilization of applied nutrients by the crop as the store of native fertility in influencing the quality of grain. It was also known that a deficient soil moisture and nutrients supply, besides sunlight and temperature, most adversely affected the differentiation of flower primordium, reductive division of pollen and embryo sac mother cells and the ultimate development of ear (Matsuo, 1959). Again, excessive rainfall could be as bad as, even worse than deficit rainfall in its influence on the nutritive quality of the grain; because the differential beneficial effect of soil types and fertility status on the nutritive quality of the grain was apparently lost under excessive rainfall, presumably due to heavier leaching of soluble nutrients from the rhizosphere of the growing plants.

No correlation was found to exist among the three nutritive elements in the grain. Thus, in the physiological process of seed formation, metabolism of these elements were not interdependent. Lack of metabolic interdependency would indicate the possibility of significant and unilateral increase in the protein content of grain by timely application of ammoniacal fertilizers alone, and this was experimentally verified.

## SUMMARY

Grain samples obtained from different sets of manurial and fertilizer trials undertaken for boosting rice yield were chemically analysed for determination of the effect of fertilizers on the nutritive value of the grain.

Puddling-time application of compost or ammonium sulphate at the rate of 30 lb. N per acre increased the grain yield by about 45 per cent over control, but had no influence on the nutritive quality of the grain. However, topdressing or foliar spraying of ammonium sulphate or urea, about three weeks before heading, significantly increased the protein content of the grain; the increase was of the order of 28 per cent over unfertilized checks. Earlier application of the same treatments had no effect. Thus, the form of nitrogen and the time of its application seemed to have a decisive influence in passing on the benefit of applied N to the qualitative improvement of the grain.

Application of water-soluble phosphate, organic phosphorus, potash and calcium at puddling time had no influence on the protein, phosphorus and calcium contents of grain.

The Gangetic alluvium soils produced grain of superior nutritive quality than lateritic soils. But this differential beneficial effect of soil type and fertility status on grain quality was not detectable under excessive rainfall.

No correlation was found to exist among the three nutritive elements in the grain; this confirmed the observation that the protein content of the grain could be increased, significantly and unilaterally, by timely application of ammoniacal fertilizers alone.

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# CONTROL OF *SCHOENOBIUS INCERTULAS* WLK., (LEPIDOPTERA, PYRALIDAE) BY THE ROUTINE APPLICATION OF BHC AND DDT

A. C. BASU and B. K. BERA

*State Agricultural Research Institute, Tollygunge, Calcutta*

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THE paddy stem borer, *Schoenobius incertulas* Wlk., (Pyralidae, Lepidoptera)—one of the most important insect pests of the paddy plant—is quite abundant in the paddy-growing tracts of West Bengal. *S. incertulas* being a borer, its control offers problems which are not easy of solution.

Before the Second World War, paddy farmers in West Bengal used to control this insect pest by the adoption of mechanical and cultural methods. With the advancement of science and introduction of insecticides like BHC and DDT in recent years, however, progressive paddy farmers do not solely depend on the age-old control methods. They are now using BHC and DDT for combating *S. incertulas*.

The general performance of BHC and DDT in controlling lepidopterous and other insects has been proved beyond doubt to be quite effective by various workers. But since the larvae of *S. incertulas* bore into the paddy culm shortly after the hatching of the eggs and spend most of their life inside the paddy culm feeding on the plant tissues, it becomes absolutely difficult to place the insecticide directly in contact with the larvae of this insect. This is why the use of insecticides as a curative measure for halting the damage of *S. incertulas* has often been proved to be unwise. However, a critical review of the habit of this insect reveals that the only chance to poison the larvae of *S. incertulas* lies mainly during the transit period from the hatching of the egg to the boring of the larvae into the paddy culm. Again, this vulnerable period being of a very short nature, the fixing of an appropriate time for the insecticidal application always involves a great risk, since, a little delay may result in a total failure of the entire venture. However, all these implications and risks may be overcome and the boring of the larvae of *S. incertulas* prevented if the paddy plantation is covered with an insecticidal film prior to the egg-laying and hatching of the larvae of *S. incertulas*. The present experiment was conducted at the State Agricultural Farm, Chinsura, a place situated 23 miles north of Calcutta, keeping this point in view.

## MATERIAL AND METHODS

The experiment was conducted for two years during 1952 and 1953, and with Bhasamanik, a variety of *aman* paddy. The seed-bed for this experiment was sown on June 16 and the seedlings from the seed-bed were transplanted on July 30. The mature crop was harvested on November 20. These operational dates were the same for both the years.

The experimental layout was in randomized block design with the plot-size of 18 ft. × 10 ft. (=180 sq. ft.) or 1/242 acre. A block consisted of five plots for accommodating five treatments, and there were 12 blocks to replicate each treatment 12 times. The 12 blocks were laid scattered in the Farm to allow the incidence of *S. incertulas* wider scope.

The insecticides selected for the experiment were BHC (Benzene hexachloride) and DDT (Dichloro-diphenyl-trichlo-roethane) which were used in two forms, viz., spray and dust. For spray, 50 per cent wettable powder, and for dust one per cent powder were used in both the cases. The spraying was done on the basis of 100 gallons of water per acre. The five treatments and the dosage used in the experiment are: (i) 2 lb. of BHC 50 per cent wettable powder (or 1 lb. active BHC)+100 gallons of water per acre, i.e., in 0·1 per cent strength; (ii) 2 lb. of DDT 50 per cent wettable powder (or 1 lb. active DDT)+100 gallons of water per acre, i.e., in 0·1 per cent strength; (iii) 50 lb. of BHC 1·0 per cent dust (or 0·5 lb. active BHC) per acre; (iv) 50 lb. of DDT 1·0 per cent dust (or 0·5 lb. active DDT) per acre and (v) control.

There were four applications of each treatment at an interval of 15 days, dates of application being August 15, August 31, September 16 and October 2, in both the years.

The data on the extent of damage done by *S. incertulas* in the treated and control plots were noted only once at the time of the harvesting of the crop. The assessment was made on the basis of the total number of healthy and damaged earheads (white earheads) recorded separately, from which the percentage of damage were calculated. While recording the number of damaged earheads, proper care was taken to avoid confusion amongst earheads damaged by *S. incertulas* Wlk., *Leptocorixa acuta* Thun. and *Helminthosporium oryzae* Breda De Hann., and sterile earheads. The earheads damaged by agencies other than *S. incertulas* were taken as healthy to avoid complications.

The data for both the years were analysed statistically and the results are shown in Tables I and II.

TABLE I. THE AVERAGE PERCENTAGE OF EARHEADS DAMAGED BY *S. INCERTULAS* NOTED IN THE EXPERIMENTAL CONTROL AND TREATED PLOTS AND THE COST OF CONTROL OPERATIONS PER ACRE

| Treatment | Year | | Cost of control operations per acre for four applications | | |
|---|---|---|---|---|---|
| | 1952 | 1953 | Insecticide | Labour* | Total |
| BHC (dust) | 0·71 | 0·73 | 5·20 nP. | 1·50 nP. | 6·70 nP. |
| BHC (spray) | 1·00 | 1·00 | 6·72 nP. | 6·00 nP. | 12·72 nP. |
| DDT (dust) | 0·99 | 0·87 | 22·40 nP. | 1·50 nP. | 23·90 nP. |
| DDT (spray) | 1·07 | 1·09 | 18·00 nP. | 6·00 nP. | 24·00 nP. |
| Control | 6·43 | 6·61 | | | |

*Spraying—one labourer covers one acre in eight hours
Dusting—one labourer covers four acres in eight hours

TABLE II. THE ANALYSIS OF VARIANCE FOR TWO YEARS (ANGLES)

| Source of variation | d.f. | 1952 | | 1953 | |
|---|---|---|---|---|---|
| | | m.s. | F | m.s. | F |
| Block | 11 | 0·735 | 1·85 | 0·559 | .. |
| Control vs. treatments | 1 | 801·910 | 2,014·85** | 852·030 | 1,183·38** |
| DDT vs. BHC | 1 | 3·500 | 8·79** | 1·470 | 2·04 |
| Between DDTs' (dust vs. spray) | 1 | 0·280 | .. | 2·510 | 3·49 |
| Between BHCs' (dust vs. spray) | 1 | 4·850 | 12·19** | 4·080 | 5·67* |
| Error | 44 | 0·398 | .. | 0·720 | |
| Total | 59 | | | | |

**Denotes 1 per cent level of significance
*Denotes 5 per cent level of significance

## RESULTS AND DISCUSSION

A good deal of work has been done on the control of *S. incertulas* in India as well as in other countries by the application of BHC and DDT. Ramachandran (1951) has found that between two concentrations of DDT and BHC at 0·5 per cent and 0·1 per cent, BHC 0·1 per cent sprays give a good protection to paddy from the attack of *S. incertulas*. Van Der Lann (1951) has observed Toxaphene 0·1 per cent spray to be superior to DDT 0·04 per cent and 0·07 per cent in respect of the control of rice borers. Kawada *et al.* (1954) have observed that the damage of *S. incertulas* can be sufficiently avoided by the application of 0·1 per cent BHC, DDT emulsion, 0·05 per cent BHC suspension or 1·0 per cent BHC dust. According to them, the first application of insecticide is done about three weeks after seeding, and one thereafter three to five applications at intervals of five days. Otanes and Sison (1952) have suggested the selection of DDT for the control of *S. incertulas*. Lal (1952) has observed that the removal of stem borer (*S. incertulas*) infested plants followed by spraying with 0·2 per cent DDT suspension or dusting with five per cent DDT give a good check to the stem borer attack. Santhanaraman (1952) has observed 0·1 per cent BHC spray to be quite good for the control of the rice stem borer. Kuwayama (1954) has described the experiments carried out in Kokkaido. According to him, in an early test BHC stood as the best, with DDT second and Chlordane almost ineffective. Ananthanarayanan *et al.* (1955) have observed that the paddy stem borer can be controlled by a timely application of two to three rounds of BHC 0·1 per cent spray. BHC ten per cent dust at the rate of 20 lb. per acre or BHC ten per cent dust plus DDT five per cent dust check the infestation of *S. incertulas*, but not like the BHC 0·1 per cent spray. Padwick (1956) has described that in Japan as an alternative to Parathion at 1·0 per cent gamma-BHC dust is used at 27 lb. per acre to prevent the

first brood from entering the stems. A 3·0 per cent gamma-BHC dust is applied at 27-36 lb. per acre when the larvae of the borer have already penetrated into the stem. Against the second-brood larvae, a 1·0 to 3·0 per cent gamma-BHC dust is applied at 36 lb. per acre.

In this experiment, August 15 was fixed for the first application. This date was selected on the basis of the data collected in another experiment " Study on the activity of *S. incertulas* in relation to weather conditions ". In that experiment, samples of the active *S. incertulas* moths were collected throughout the year with the help of two light traps as described by Banerjee and Basu (1956). The five years' data of that experiment show that *S. incertulas* in the *aman* season begins to fly $\pm$ 5 days of the August 20. Apparently, it was thought to be appropriate to apply the insecticidal coverage straight from the August 15. The other experiments with this insect, *S. incertulas*, show that this insect damages the *aman* paddy at Chinsurah up to October 15. So, in conformity to these observations, four applications of the insecticides were prescribed in this experiment to shield the paddy plantation from the damage of *S. incertulas*. Again, since four applications were made for each treatment, it is considered to be quite adequate to use BHC and DDT at the ordinary strength. This is why 1 lb. active BHC and DDT per acre in the spray and 0·5 lb. active BHC and DDT per acre in the dusting were rated in this experiment.

In the experiment for spraying insecticide 100 gallons of water, and for dusting insecticide 50 lb. of powder were used for two considerations. Firstly, it was a part of the experiment to drench the paddy plants during the first two applications and to spray the paddy plants thoroughly during the last two applications. Further, it was a point to keep the volume constant for all the applications to avoid complications (of variant dosages) amongst the farmers when such results are advocated for practice. Secondly, the paddy plants grow in size with age, so with the volume of spraying and dusting materials required to cover the paddy plants at the time of the first application, it is not possible to cover squarely the paddy plants at the stage of the crop when the fourth application is given. Whereas with the reverse it is quite possible to drench the paddy plants in the first and second stages of the crop when the first and second applications are given. Evidently, it was decided to fix a uniform rate of application per acre at 100 gallons of water for spraying and 50 lb. of powder for dusting. Now, from the experiences of the experiments, it has been observed that with the aforesaid rate the paddy plants can be drenched satisfactorily in the first two applications, and with the same volume of materials the paddy plants can be covered thoroughly in the last two applications.

In reviewing the results shown in Tables I and II, it is noticed that in both the years the percentage of damage was significantly higher in the control or untreated plots than in the other plots treated with the insecticides, proving thereby that the routine application of BHC or DDT in any form can protect the paddy plantation from the damage of *S. incertulas*. Further, a comparison between BHC and DDT reveals that no significant difference does exist, so both the insecticides are equally good for the purpose of protecting the paddy crop from the infestation. Between the methods of application, i.e., dusting and spraying, in DDT no significant difference is noticed, so the spraying of DDT stands equally good as dusting. But

between the two methods of applying BHC, the dusting method has a significant response than the spraying method. The dusting of BHC stands, therefore, superior to spraying. Further, the price structure, as evidenced in the Table I, also strengthens the conclusion that the dusting of BHC is most economical and effective when used as a prophylactic measure against the infestation of *S. incertulas*.

In assessing the resultant income derived per acre by the routine applications of insecticides, it is seen, according to the result of 1952, that the four applications of BHC (dust) have protected (6·43-0·73 per cent=) 5·72 per cent earheads. On the basis of 20 md. (746 kilograms) of clean rice per acre, 5·72 per cent protection of earheads contributes an extra yield of 1·144 md. (42·33 kilograms) of clean rice, the price of which comes to Rs. 32·03 (at the rate of Rs. 28·00 per md.). The net profit, therefore, works out at (Rs. 32·03-Rs. 6·70=) Rs. 25·33 per acre when BHC (dust) is used as a prophylactic measure. Similarly, the profit per acre by BHC (spray) works out at Rs. 17·69, DDT (dust) Rs. 6·56 and DDT (spray) Rs. 6·02. Again, in evaluating the economics in respect of the experimental result of 1953, it is seen that each prophylactic treatment of BHC (dust), BHC (spray), DDT (dust) and DDT (spray) returns a net profit of Rs. 26·23, Rs. 18·70, Rs. 8·24 and Rs. 6·91 respectively, per acre. It can, therefore, be concluded that both BHC and DDT are effective in the control of *S. incertulas* in paddy and that BHC (dust) and BHC (spray) are both more economical than DDT.

## SUMMARY AND CONCLUSION

Experiments were conducted for two years to study the effect of four routine applications of BHC and DDT in two forms of dust and suspension spray in a randomized field layout. The four dates of insecticidal applications were August 15, August 31, September 16 and October 2 in both the years.

The treatments selected were: (i) BHC spray in 0·1 per cent strength, (ii) DDT spray in 0·1 per cent strength, (iii) BHC 1·0 per cent dust at 50 lb. per acre, (iv) DDT 1·0 per cent dust at 50 lb. per acre and (v) control. Individual treatment was replicated 12 times in plots measuring 18 ft. × 10 ft. The entire data and the economics of the different treatments have been explained.

From the experimental results, it is concluded that the routine application of insecticides can protect paddy plantation from the borer attack. Between BHC and DDT, there is no significant difference, proving thereby that both are equally suitable in protecting the infestation of *S. incertulas*. Similarly, between the two methods of applying DDT, there exists no significant difference. But compared to the BHC spray, BHC dust is significantly more effective in checking the infestation of *S. incertulas* and is the most economical amongst the different treatments.

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# NITRIFICATION OF SOME SUMMER WILD LEGUMES IN SOIL

N. B. PAUL and ABHISWAR SEN

*Indian Agricultural Research Institute, New Delhi*

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Legumes have been universally used as green manure crops. The suitability of a particular legume as green manure depends on its rate of decomposition or nitrification in the soil. Joshi (1919) had shown that the rates of nitrification of some cultivated and wild legumes in a calcareous soil at Pusa were different. Such differences in their rates of nitrification were also observed by Idnani and Chibber (1956) who had reported results of nitrification experiments with a large number of summer and winter legumes. During the present investigation, nitrification of green matter from eleven summer wild legumes and that of sannhemp, a common green manure crop in India, have been studied along with solubilization of phosphate, if any, during the decomposition of the organic matter in the soil. These legumes had been studied earlier by the authors (Sen and Paul, 1959), who found that some of these legumes, when growing under natural conditions, increased both the carbon and nitrogen contents of the soils to an appreciable extent.

## MATERIAL AND METHODS

The following wild legumes were collected at the pre-flowering stage, dried and sampled for the present studies: (i) *Desmodium purpureum*, (ii) *Alysicarpus rugosus*, (iii) *Aeschynomene aspera*, (iv) *Stizolobium deeringianum*, (v) *Clitoria ternatea*, (vi) *Tephrosia purpurea*, (vii) *Phaseolus lathyroides*, (viii) *Cassia accidentalis*, (ix) *Crotalaria mucronata*, (x) *Stizolobium cochinchinensis*, (xi) *Dolichos lablab*, and (xii) *Crotalaria juncea.*

The relative growth of these legumes in the Delhi soil, based on collection of plants growing under natural conditions from equal areas, is given in Appendix II, the composition of the dry organic matter in Appendix I and the composition of the soil in Appendix III.

The samples were so mixed with the Delhi soil (0·9 in.) sampled through a 2 mm. sieve as to supply 30 mg. of nitrogen per 100 gm. of soil in duplicate sets. The soils with the legumes were moistened to one-third their saturation capacities and incubated for three months at 30° C. The loss of moisture was made up periodically by the addition of water. At intervals of two weeks, samples were taken out for estimation of (1) organic nitrogen, (2) $NH_4$-N, (3) $NO_3$-N, (4) water soluble $P_2O_5$ and (5) lignin.

Ten grammes of soil were leached with 500 cc. of N, NaCl solution. The residue after leaching on the filter-paper was digested by the Kjeldahl-Gunning method of digestion for organic N. The leachate was distilled with alkali for the estimation of $NH_4$-N (McLean and Robinson, 1924). The alkaline liquid residue was then distilled with 1 gm. of Devarda's alloy for the estimation of $NO_3$-N (Wright, 1934).

The rates of nitrification were calculated from the values $r_{xy} = \frac{\delta y}{\delta x}$, where r is the correlation co-efficient between x (period in weeks), and y (mg. N as $NO_3$ per 100 gm. of soil),

$$\delta y = \sqrt{\frac{\Sigma y^2}{n} - \left(\frac{\Sigma y}{n}\right)^2}, \quad \delta x = \sqrt{\frac{\Sigma x^2}{n} - \left(\frac{\Sigma x}{n}\right)^2}$$

and n, the number of observations (Shaw, 1936).

The water-soluble $P_2O_5$ in the soil was estimated colorimetrically in a 1:5 water extract of the soil (A.O.A.C., 1940). The lignin content of the plant materials was estimated by the method of Mahood and Cable (1922).

## RESULTS

The organic N, $NH_4$-N and $NO_3$-N contents of the soil mixed with organic matter from different wild legumes at different periods are given in Table I.

TABLE I. NITROGEN CONTENT OF THE DELHI SOIL UNDER DIFFERENT GREEN MANURE TREATMENTS AT DIFFERENT PERIODS

(Expressed as mg. per cent on dry basis)

| | At start | 2 weeks | 4 weeks | 6 weeks | 8 weeks | 10 weeks | 12 weeks |
|---|---|---|---|---|---|---|---|
| | Delhi soil (Untreated) | | | | | | |
| Org. N | 50·00 | 49·00 | 50·00 | 50·00 | 50·00 | 50·00 | 50·00 |
| $NH_4$-N | 2·50 | 2·22 | 3·72 | 2·25 | 1·50 | 0·52 | 1·00 |
| $NO_3$-N | 0·45 | 2·10 | 3·24 | 3·48 | 3·48 | 4·08 | 4·38 |
| Total | 52·95 | 53·32 | 56·96 | 55·73 | 54·98 | 54·60 | 55·38 |
| | *Desmodium purpureum* | | | | | | |
| Org. N | 81·00 | 83·00 | 83·00 | 81·00 | 79·00 | 78·00 | 79·00 |
| $NH_4$-N | 2·50 | 4·48 | 4·51 | 4·54 | 3·76 | 2·11 | 2·50 |
| $NO_3$-N | 0·45 | 1·05 | 4·38 | 5·28 | 5·88 | 6·24 | 7·26 |
| Total | 83·95 | 88·53 | 91·89 | 90·82 | 88·64 | 86·35 | 88·76 |
| | *Alysicarpus rugosus* | | | | | | |
| Org. N | 80·00 | 83·00 | 81·00 | 81·00 | 79·00 | 78·00 | 77·00 |
| $NH_4$-N | 2·50 | 4·42 | 3·76 | 3·03 | 2·26 | 3·15 | 1·02 |
| $NO_3$-N | 0·45 | 2·16 | 4·80 | 5·46 | 7·68 | 7·86 | 7·86 |
| Total | 82·95 | 89·58 | 89·56 | 89·49 | 88·94 | 89·01 | 85·88 |

TABLE I. (*Contd.*)

| | At start | 2 weeks | 4 weeks | 6 weeks | 8 weeks | 10 weeks | 12 weeks |
|---|---|---|---|---|---|---|---|
| | | | | *Aeschynomene aspera* | | | |
| Org. N | 85·00 | 81·00 | 81·00 | 79·00 | 81·00 | 78·00 | 79·00 |
| $NH_4$-N | 2·50 | 3·73 | 4·43 | 3·72 | 2·98 | 2·09 | 1·01 |
| $NO_3$-N | 0·45 | 5·10 | 9·84 | 10·32 | 12·30 | 12·54 | 12·30 |
| Total | 87·95 | 89·83 | 95·27 | 93·04 | 96·28 | 92·63 | 92·31 |
| | | | | *Stizolobium deeringianum* | | | |
| Org. N | 81·00 | 80·00 | 81·00 | 79·00 | 79·00 | 79·00 | 79·00 |
| $NH_4$-N | 2·50 | 4·50 | 4·54 | 3·80 | 2·25 | 1·05 | 1·95 |
| $NO_3$-N | 0·45 | 1·65 | 4·80 | 5·28 | 6·24 | 6·48 | 6·84 |
| Total | 83·95 | 86·15 | 90·34 | 88·08 | 87·49 | 86·53 | 87·79 |
| | | | | *Clitoria ternatea* | | | |
| Org. N | 81·00 | 80·00 | 77·00 | 78·00 | 81·00 | 77·00 | 77·00 |
| $NH_4$-N | 2·50 | 5·97 | 5·93 | 4·50 | 5·28 | 3·15 | 1·99 |
| $NO_3$-N | 0·45 | 5·10 | 9·84 | 9·84 | 10·50 | 11·70 | 12·54 |
| Total | 83·95 | 91·07 | 92·77 | 92·34 | 96·78 | 91·85 | 91·53 |
| | | | | *Tephrosia purpurea* | | | |
| Org. N | 80·00 | 82·00 | 79·00 | 81·00 | 81·00 | 78·00 | 79·00 |
| $NH_4$-N | 2·50 | 5·96 | 3·00 | 3·03 | 3·74 | 2·09 | 1·91 |
| $NO_3$-N | 0·45 | 5·40 | 10·08 | 10·08 | 10·32 | 10·32 | 11·28 |
| Total | 82·95 | 93·36 | 92·08 | 94·11 | 95·06 | 90·41 | 92·19 |
| | | | | *Phaseolus lathyroides* | | | |
| Org. N | 80·00 | 79·00 | 77·00 | 79·00 | 79·00 | 79·00 | 79·00 |
| $NH_4$-N | 2·50 | 3·72 | 3·77 | 3·78 | 3·03 | 1·07 | 2·07 |
| $NO_3$-N | 0·45 | 4·50 | 8·88 | 9·30 | 9·84 | 9·84 | 10·50 |
| Total | 82·95 | 87·22 | 89·65 | 92·08 | 91·87 | 89·91 | 91·57 |
| | | | | *Cassia occidentalis* | | | |
| Org. N | 80·00 | 80·00 | 79·00 | 79·00 | 81·00 | 78·00 | 79·00 |
| $NH_4$-N | 2·50 | 5·92 | 3·72 | 3·74 | 2·23 | 2·09 | 3·07 |
| $NO_3$-N | 0·45 | 1·35 | 3·42 | 4·38 | 4·80 | 4·80 | 6·24 |
| Total | 82·95 | 87·27 | 86·14 | 87·12 | 88·03 | 84·89 | 88·31 |

TABLE I. (*Concld.*)

| | At start | 2 weeks | 4 weeks | 6 weeks | 8 weeks | 10 weeks | 12 weeks |
|---|---|---|---|---|---|---|---|
| | | | | *Crotalaria mucronata* | | | |
| Org. N | 81·00 | 81·00 | 78·00 | 79·00 | 78·00 | 79·00 | 79·00 |
| $NH_4$-N | 2·50 | 3·71 | 3·73 | 3·01 | 2·29 | 3·20 | 1·03 |
| $NO_3$-N | 0·45 | 1·05 | 4·02 | 4·80 | 5·28 | 6·84 | 7·26 |
| Total | 83·95 | 85·76 | 85·75 | 86·81 | 85·57 | 89·04 | 87·29 |
| | | | | *Stizolobium cochinchinensis* | | | |
| Org. N | 83·00 | 82·00 | 79·00 | 81·00 | 79·00 | 81·00 | 79·00 |
| $NH_4$-N | 2·50 | 2·97 | 4·52 | 2·30 | 2·28 | 3·21 | 2·08 |
| $NO_3$-N | 0·45 | 3·90 | 6·84 | 6·84 | 8·10 | 8·28 | 8·88 |
| Total | 85·95 | 88·87 | 90·36 | 90·14 | 89·38 | 92·49 | 89·96 |
| | | | | *Dolichos lablab* | | | |
| Org. N | 83·00 | 81·00 | 79·00 | 79·00 | 79·00 | 78·00 | 78·00 |
| $NH_4$-N | 2·50 | 4·49 | 6·71 | 3·06 | 2·99 | 2·09 | 1·51 |
| $NO_3$-N | 0·45 | 6·90 | 10·50 | 10·92 | 11·70 | 11·70 | 13·32 |
| Total | 85·95 | 92·39 | 96·21 | 92·98 | 93·69 | 91·79 | 92·83 |
| | | | | *Crotalaria juncea* | | | |
| Org. N | 81·00 | 80·00 | 78·00 | 77·00 | 77·00 | 78·00 | 79·00 |
| $NH_4$-N | 2·50 | 2·98 | 6·00 | 3·00 | 2·24 | 2·10 | 2·04 |
| $NO_3$-N | 0·45 | 3·30 | 7·26 | 7·86 | 8·88 | 8·88 | 8·88 |
| Total | 83·95 | 86·28 | 91·26 | 87·86 | 88·12 | 88·98 | 89·92 |

It is seen from the data in Table I, that while the organic N content of the untreated Delhi soil remained more or less constant throughout the period of three months, that in the treated soils diminished at the end of 12 weeks. The diminution in organic N did not take place at a uniform rate. The content of $NH_4$-N in the treated soils varied irregularly at different periods. This is also observed in the case of the untreated soil. $NO_3$-N content of the soils treated or untreated, increased with progress of time.

There was some evidence of N fixation in all the cases. From the total N content, i.e., the sum total of organic, $NH_4$- and $NO_3$-N of the soils, it was evident, that the N content of the soils increased and attained a peak after some time and then decreased

to some extent. Even after the fall in the total N, the N contents at the end of 12 weeks were still higher than the original N content of the soil. The peak period varied from two to ten weeks.

It was also observed that the increases in the N content over the original at the end of 12 weeks varied from 2·93 (*A. rugosus*) to 9·24 (*T. purpurea*) mg. per cent and were all higher than in the case of untreated soil, where an increase of 2·43 mg. of N was observed.

The amounts of water-soluble $P_2O_5$ at different periods in the soil under treatment with different wild legumes are given in Table II.

TABLE II. WATER-SOLUBLE PHOSPHATE ($P_2O_5$) IN SOIL DURING DIFFERENT PERIODS OF DECOMPOSITION

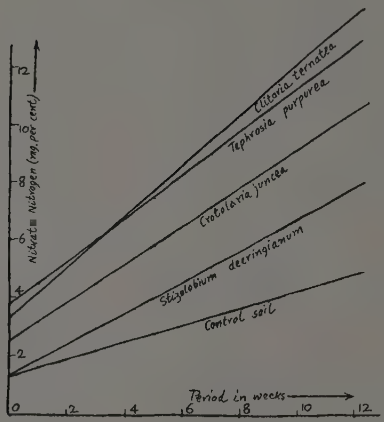
(Expressed as mg. per cent on dry basis)

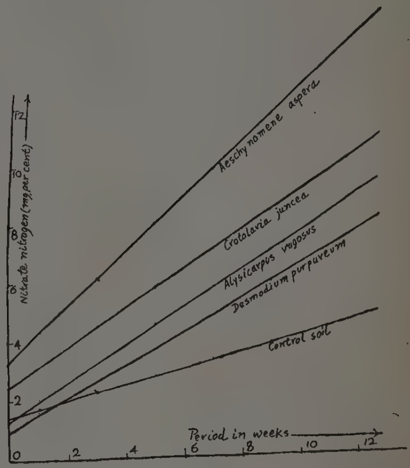
| Wild legumes | At start | 2 weeks | 4 weeks | 6 weeks | 8 weeks | 10 weeks | 12 weeks | Mg. $P_2O_5$ supplied per cent in the form of wild legume |
|---|---|---|---|---|---|---|---|---|
| No wild legume | 1·63 | 1·21 | 1·47 | 1·56 | 1·56 | 1·08 | 1·49 | .. |
| *D. purpureum* | 1·88 | 1·17 | 1·67 | 1·81 | 1·05 | 1·31 | 1·26 | 6·55 |
| *A. rugosus* | 1·74 | 1·17 | 1·51 | 1·83 | 1·33 | 1·44 | 1·17 | 6·17 |
| *A. aspera* | 1·15 | 1·37 | 1·28 | 1·65 | 1·56 | 0·94 | 1·35 | 7·10 |
| *S. deeringianum* | 1·90 | 1·37 | 1·24 | 1·78 | 1·47 | 1·44 | 1·63 | 4·34 |
| *C. ternatea* | 1·95 | 1·19 | 1·37 | 1·67 | 1·51 | 1·24 | 1·44 | 1·05 |
| *T. purpurea* | 1·37 | 1·31 | 0·85 | 1·51 | 1·08 | 1·35 | 1·40 | 1·53 |
| *P. lathyroides* | 1·72 | 0·87 | 0·87 | 1·31 | 1·24 | 1·03 | 1·17 | 6·22 |
| *C. occidentalis* | 1·15 | 0·82 | 1·08 | 1·70 | 1·63 | 1·19 | 1·21 | 6·91 |
| *C. mucronata* | 1·81 | 0·99 | 1·33 | 1·53 | 1·37 | 1·05 | 1·65 | 5·44 |
| *S. cochinchinensis* | 1·67 | 1·31 | 1·56 | 1·53 | 1·53 | 1·35 | 1·67 | 8·22 |
| *D. lablab* | 1·24 | 0·96 | 1·33 | 1·56 | 1·33 | 1·17 | 1·31 | 1·92 |
| *C. juncea* | 1·49 | 1·12 | 1·28 | 1·65 | 1·60 | 1·24 | 1·47 | 2·14 |

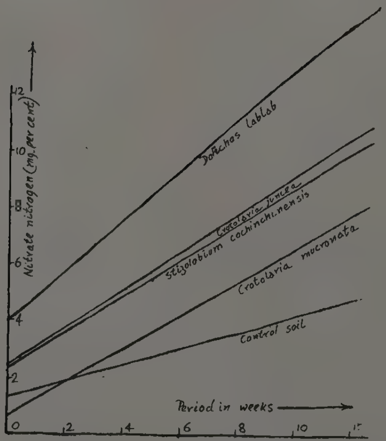
It is observed from the data in Table II that at the very start, water-soluble $P_2O_5$ increased over the cotrol in the case of *D. purpureum*, *A. rugosus*, *S. deeringianum*, *C. ternatea*, *P. lathyroides*, *C. mucronata*, and *S. cochinchinensis*, and decreased under *A. aspera*, *T. purpurea*, *C. occidentalis*, *D. lablab* and *C. juncea*. The water-soluble $P_2O_5$ content varied irregularly throughout the period, at the end of 12 weeks increases in water-sobluble $P_2O_5$ over the untreated soil; though less than the original $P_2O_5$ content, could be observed only in the case of *S. deeringianum* and *C. mucronata*. The water-soluble $P_2O_5$ content of the soil treated with *S. cochinchinensis* at start and after 12 weeks, remained unchanged. There were increases in the water-soluble $P_2O_5$ content of the soil treated with *A. aspera*, *T. purpurea*, *C. occidentalis* and *D. lablab* over

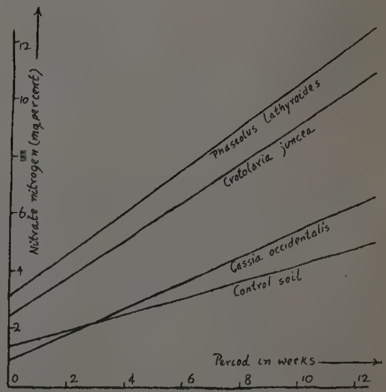
their originals after a period of 12 weeks. After the start of the experiment, the increases in the water-soluble $P_2O_5$ content reached their maximum at sixth week in all the treatments except *C. mucronata* and *S. cochinchinensis*, where the maximum reached after 12 weeks.

The data in Tables I and II are graphically illustrated as below.



## DISCUSSION

It is observed from the data given in Table I that there is no regular tendency of the organic, $NH_4$- or total N of the untreated soil and the soil treated with wild legumes to increase or decrease with the progress of time. At least up to 12 weeks, however, the $NO_3$-N of the soil shows an increase. The correlation between $NO_3$-N and time is highly significant in the case of all the treatments. The rates of increase, when the data are analysed statistically, come out to be different for soil treated with different wild legumes. The rates of increase of $NO_3$-N in the soil are given in Table III.

TABLE III. RATE OF NITRIFICATION OF DIFFERENT WILD LEGUMES

| Wild legumes | Rate of nitrification (mg./week) | Correlation/coefficient between x (no. of weeks) and y (mg. $NO_3$-N per 100 gm. of soil) | Relationship |
|---|---|---|---|
| Nil | 0·29 | 0·9156 | $y = 1{\cdot}34 + 0{\cdot}29\,x$ |
| *D. purpureum* | 0·58 | 0·8592 | $y = 0{\cdot}88 + 0{\cdot}58\,x$ |
| *A. rugosus* | 0·65 | 0·9540 | $y = 1{\cdot}28 + 0{\cdot}65\,x$ |
| *A. aspera* | 0·94 | 0·8938 | $y = 3{\cdot}31 + 0{\cdot}94\,x$ |
| *S. deeringianum* | 0·54 | 0·9342 | $y = 1{\cdot}29 + 0{\cdot}54\,x$ |
| *C. ternatea* | 0·89 | 0·9013 | $y = 3{\cdot}23 + 0{\cdot}89\,x$ |
| *T. purpurea* | 0·76 | 0·8331 | $y = 3{\cdot}71 + 0{\cdot}76\,x$ |
| *P. lathyroides* | 0·75 | 0·8779 | $y = 3{\cdot}12 + 0{\cdot}75\,x$ |
| *C. occidentalis* | 0·46 | 0·9607 | $y = 0{\cdot}87 + 0{\cdot}46\,x$ |
| *C. mucronata* | 0·59 | 0·9719 | $y = 0{\cdot}70 + 0{\cdot}59\,x$ |
| *S. cochinchinensis* | 0·63 | 0·9057 | $y = 2{\cdot}40 + 0{\cdot}63\,x$ |
| *D. lablab* | 0·88 | 0·8678 | $y = 4{\cdot}08 + 0{\cdot}88\,x$ |
| *C. juncea* | 0·67 | 0·8759 | $y = 2{\cdot}48 + 0{\cdot}67\,x$ |

It is observed from the data given in Table III that the rates of nitrification in soils treated with different wild legumes are higher than in the untreated soil, and that the highest rate of nitrate formation occurs in the case of *A. aspera*, closely followed by the creepers *C. ternatea* and *D. lablab*. *C. juncea* is commonly used as a green manure crop practically all over India. It is observed that a large number of wild legumes like *A. aspera*, *C. ternatea*, *T. purpurea*, *P. lathyroides* and *D. lablab* show a higher rate of

nitrification than *C. juncea*. Among them, *A. aspera* yields a large quantity of organic matter per acre (Appendix II). From the data in Appendix II, it is also clear that apart from *A. aspera*, with its high yield and high rate of nitrification, *C. mucronata*, *A. rugosus* and *Stizolobium* spp. can as well be utilized for use as green manures inspite of their low rates of nitrification. When correlations are worked out between the rates of nitrification of different wild legumes and their nitrogen, the $P_2O_5$ or lignin contents, either singly or jointly, it is observed that they are not significant. It is fair to assume, therefore, that the differences in the rates of nitrification of different wild legumes are not due to their composition but to the quality of the protein content in them and the presence or formation of toxic substances in the wild legumes during their decomposition in the soil.

As a result of the addition of wild legumes to soil, an extra addition of 1·05 to 8·22 mg. $P_2O_5$ per 100 gm. of the soil contained in the plant material has been effected (Table II). After the start of the experiment, there was a general tendency for the water-soluble $P_2O_5$ content to increase to a maximum after six weeks and to decrease later on up to twelve weeks in all the treatments except *S. cochinchinensis* and *C. mucronata*. While solubilization of $P_2O_5$ may occur due to phosphate-solubilizing bacteria, the decrease to utilization by soil organisms and fixation and reversion of the soluble phosphate in the soil, the water-soluble $P_2O_5$ increases over the untreated soil only in the case of *Stizolobium* spp. and *C. mucronata* at the end of 12 weeks. The water-soluble $P_2O_5$ content of the soils and the amounts of $NO_3$-N at different periods also appear to bear no relationship with each other. This shows that no remarkable increase in the water-soluble $P_2O_5$ occurs in the soil as a result of incorporation of wild legumes in the soil.

Based on the rates of nitrification of the wild legumes, which represent, to a fair degree their rate of decomposition in soil, it is not possible to explain why certain legumes, under natural conditions enrich a soil with nitrogen and certain others with organic carbon and others with both carbon and nitrogen, and why certain others fail to increase either the nitrogen or carbon content of the soil. It is possible that it is related to the production of dry matter along with the rate of decomposition of the organic matter in the soil, or it may be related to the quality of the protein matter of different wild legumes.

## SUMMARY AND CONCLUSION

The nitrification of eleven summer wild legumes was studied in the Delhi soil along with that of sannhemp. It was observed that several wild legumes like *A. aspera*, *C. ternatea*, *T. purpurea*, *P. lathyroides* and *D. lablab* nitrified at much higher rates in the Delhi soil. The rates of nitrification of the wild legumes did not bear any relationship with their nitrogen, $P_2O_5$ or lignin content.

There was no appreciable solubilization of phosphates during the nitrification of wild legumes in the soil nor any relationship was observed between the two processes.

APPENDIX I. COMPOSITION OF THE DIFFERENT WILD LEGUMES AT THE PRE-FLOWERING STAGE (Expressed as per cent on dry basis)

| Wild legumes | Nitrogen | $P_2O_5$ | Lignin |
|---|---|---|---|
| *D. purpureum* | 2·06 | 0·45 | 25·80 |
| *A. rugosus* | 2·19 | 0·45 | 30·71 |
| *A. aspera* | 3·00 | 0·71 | 30·80 |
| *S. deeringianum* | 2·28 | 0·33 | 38·22 |
| *C. ternatea* | 2·86 | 0·10 | 29·65 |
| *T. purpurea* | 2·36 | 0·12 | 25·70 |
| *P. lathyroides* | 2·24 | 0·39 | 22·75 |
| *C. occidentalis* | 2·04 | 0·47 | 23·90 |
| *C. mucronata* | 2·70 | 0·49 | 25·45 |
| *S. cochinchinensis* | 2·52 | 0·69 | 31·95 |
| *D. lablab* | 2·66 | 0·17 | 20·55 |
| *C. juncea* | 2·66 | 0·19 | 22·25 |

APPENDIX II. YIELD OF DRY MATTER AND NITROGEN CONTAINED IN SOME SUMMER WILD LEGUMES GROWING AT DELHI DURING ONE YEAR

| Wild legumes | Average dry weight of a plant (gm.) | Per cent N | Average number of plants per plot (4′-10″ × 5′-6″) | Dry matter in lb. per acre | Nitrogen in lb. per acre |
|---|---|---|---|---|---|
| *D. purpureum* | 29·2 (33·0, 24·0, 30·5) | 2·06 | 26·7 (15, 30, 35) | 2,838 | 58 |
| *A. rugosus* | 30·3 (15·5, 8·3, 67·0) | 2·19 | 27·7 (30, 25, 28) | 3,055 | 67 |
| *A. aspera* | 35·0 (33·0, 37·0, 34·5) | 3·00 | 32·0 (30, 34, 32) | 4,077 | 122 |
| *S. deeringianum* | *1,270·0 (1,270·0) | 2·28 | 9·0 (9, 9, 9) | 41,600 | 948 |
| *C. ternatea* | 12·0 (15·0, 10·5, 10·5) | 2·86 | 10·3 (10, 11, 10) | 451 | 13 |
| *T. purpurea* | 3·83 (2·0, 7·5, 2·0) | 2·36 | 30·3 (26, 40, 25) | 423 | 10 |
| *P. lathyroides* | 6·33 (5·3, 7·5, 6·2) | 2·24 | 32·0 (30, 34, 32) | 737 | 17 |
| *C. occidentalis* | 47·8 (47·0, 49·2, 47·2) | 2·04 | 8·3 (9, 8, 8) | 1,449 | 30 |
| *C. mucronata* | 17·7 (13·0, 9·0, 31·0) | 2·70 | 48·7 (50, 56, 40) | 3,137 | 85 |
| *S. cochinchinensis* | *770·0 (770·0) | 2·52 | 9·0 (9, 9, 9) | 25,230 | 636 |
| *D. lablab* | 12·7 (20·0, 5·0, 13·0) | 2·66 | 9·0 (9, 8, 9) | 416 | 11 |

*Weight of a single plant

## APPENDIX III. COMPOSITION OF THE DELHI SOIL

(Constituents expressed as gm. per cent on moisture-free basis)

| Constituent | Per cent |
|---|---|
| Sand | 65·53 |
| Silt | 21·35 |
| Clay | 13·12 |
| pH | 7·80 |
| $CaCO_3$ | 1·43 |
| Organic C | 0·33 |
| Organic N | 0·050 |
| $NH_4$-N | 0·0025 |
| $NO_3$-N | 0·0005 |
| Total $P_2O_5$ | 0·0452 |
| Water-soluble $P_2O_5$ | 0·0016 |

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# ON THE CHALCIDOID PARASITES OF THE JUTE STEM GIRDLER FROM WEST BENGAL

N. DUTT

*Jute Agricultural Research Institute, Barrackpore, W. Bengal,* and

CH. FERRIERE

*Museum d'Histoire Naturelle, Geneva, Switzerland*

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The present chalcidoid parasites were recorded in the larval and pupal stages of the jute stem girdler, *Nupserha bicolor* Thoms. ssp. *postbrunnea* Dutt, on the farm of the Jute Agricultural Research Institute, Barrackpore, West Bengal, during 1953. The parasites have now firmly established themselves on this lamiid beetle and high incidences of parasitism are now an almost regular annual feature. These parasites have lately been found on the same host in other localities of West Bengal.

The two species of Pteromalids appear to be new and are described here. They both belong to a subfamily which has been called Metasteninae, but which is now better known under the name of Dinarminae.

Since Ashmead erected the genus *Neocatolaccus* in 1904, a dozen species have been described, but some of them certainly do not belong here. Only one species, *N. indicus* (Ayyar and Mani, 1937), has been reported from India. It has, however, been pointed out (Ferriere, 1939) that *N. indicus* is probably a synonym of *Anisopteromalus* (=*Aplastomorpha*) *calandrae* Howard.

One of our species, owing to the presence of three annelli in the antenna of the female, its short propodeum without nucha and its elongated abdomen, is a true *Neocatolaccus*. It differs from *N. indicus* in the following characters.

The female larger in size, antennae inserted slightly above the lower level of the eyes; the first two funicle joints almost equal in size, the following joints gradually shorter; thorax with white pubescence; marginal vein almost half the length of the submarginal vein; distal ends of tibia and tarsus almost white; abdomen longer than head and thorax together.

## NEOCATOLACCUS NUPSERHAE SP. NOV.

♀ Head and thorax dark green, almost black. Antennae, tegulae, wing nervature brown. Propodeum shiny.

Head rounded in front, punctate, rugulose, with striations diverging from clypeus; frons swollen, cheeks large, almost as broad as the eyes; both mandibles 4-dentate; head seen from above transverse, vertex narrow, lateral ocelli closer to the median ocellus than to the margin of the eyes; interocellar space greater than the ocular-ocellar space. Antennae inserted slightly above the lower ocular border. Scape slightly curved, reaching the median ocellus; pedicel twice as long as broad, three transverse annelli, the third little larger than the others; first funicle joint longer and

broader than the pedicel, the three following joints subequal in length, gradually broader, the last joint the shortest; club with three joints, oval, little longer than the two preceeding joints together.

Thorax rugulose, punctate, covered with white pubescence; pronotum very short, mesonotum slightly longer than broad, parapsidal furrows incomplete; scutellum a little shorter than broad; propodeum without nucha, the spiracles large and almost rectangular. Forewing with slight discoidal ciliation at the base; marginal vein somewhat thickened and almost half the length of the submarginal; stigmal vein shorter than the postmarginal and half as long as the marginal. Legs strong, trochanter brown to yellowish, femora deep brown, distal tibial ends and tarsus almost white; hind tibiae slightly longer than femora, with two unequal spurs.

Abdomen with a greenish-coppery shine, oval, pointed behind, longer than head and thorax together; ovipositor very slightly protruding (Fig. 1).

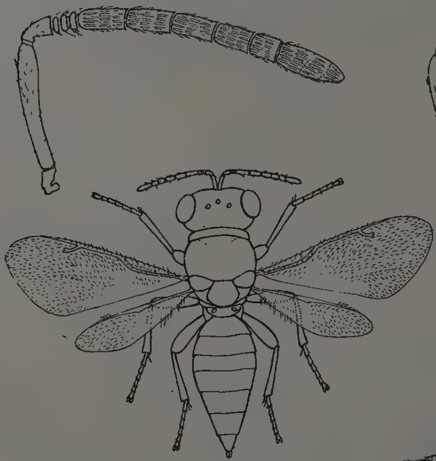

FIG. 1.

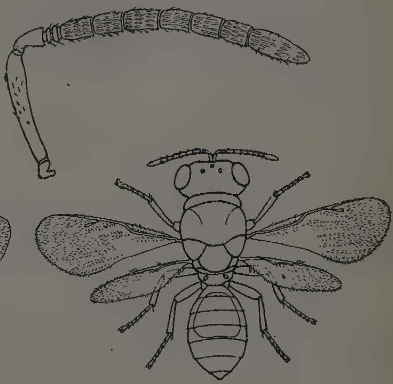

FIG. 2.

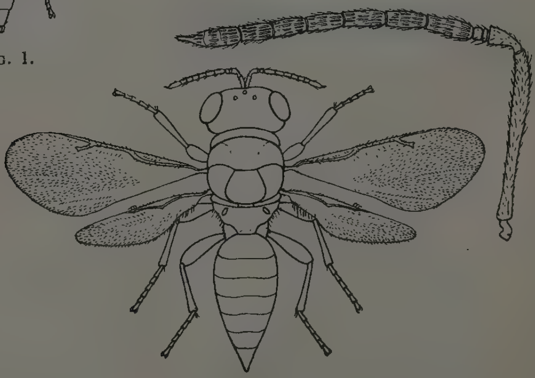

FIG. 3.

♂ Smaller than the female. Antennae with two annelli and six funicle joints. Distal tibial ends and tarsi whitish; hind tibiae with two spurs. Abdomen oval, almost equal to thorax; anterior abdominal portion white centrally (Fig. 2). In the genitalia, the distal phallobasic lobe bears two to three denticles.

Length: ♀ 3-6 mm.; ♂ 1·8-3·4 mm.

Holotype ♀, allotype ♂ will be deposited in the collection of the Zoological Survey of India, Calcutta; paratypes ♀ and ♂ at the Jute Agricultural Research Institute and at the Museum d'Histoire Naturelle, Geneva, Switzerland.

The second species belongs to the genus *Norbanus* Walker 1843 (=*Picroscytus* Thomson, 1878), which is widely distributed in several countries. Five species are known from South-East Asia, one of which, *Picroscytus indorum* Masi (1927) from the vicinity of Chilka lake in India. Szelenyi (1941) has given a key of most species, in which *N. indorum* Masi, with also *birmanus* Masi, *sumatranus* Masi and *modiglianii* Masi, is placed in the subgenus *Masioscytus* Szel., owing to the absence of a spine at the end of the antennae. With a distinct spine at the tip of the antennal club and the left mandible 3-dentate, the present species belongs to *Norbanus* Walk. sens. str., as defined by Szelenyi.

The species is related to *Picroscytus ruschkae* Masi from Formosa, but differs from it in the following characters: antennae almost black, with the basal third of the scape brown; hind tibiae with the proximal third and the distal third whitish.

## NORBANUS ACUMINATUS SP. NOV.

♀ Head and thorax almost black with white setae. Antennae black or brownish black, the basal third of scape brown. Legs brown, coxae, and femora blackish, knees and apical third of tibiae whitish. Abdomen with greenish coppery shine.

Head rounded in front, rugulose, punctate, with striations diverging from clypeus; frons swollen, cheeks almost as broad as the eyes. Right mandible 4-dentate, left mandible 3-dentate. Seen from above the head is transverse, vertex narrow, ocelli forming a low triangle, the lateral ocelli closer to the median ocellus than to the margin of the eyes; interocellar space almost equal to the ocular-ocellar space. Antennae inserted at the same level or slightly below the lower margin of the eyes; scape slightly curved, reaching the median ocellus; pedicel twice as long as broad, two transverse annelli, the second twice as long as the first; six funicle joints, the first longer than the pedicel, the fifth and sixth shorter than the others; club with three joints almost equal to the two preceding joints together, the apical segment terminating in a spine.

Thorax punctate, arched, pronotum very short, mesonotum slightly broader than long with the parapsidal furrows incomplete; scutellum a little shorter than broad; propodeal spiracles large and almost rectangular. Forewings with slight discoidal ciliation, marginal vein almost as long as the submarginal, postmarginal vein a little shorter than the marginal, stigmal vein almost as long as two-fifth of the marginal. Legs strong, hind femora thicker than the others, hind tibiae slightly longer than the hind femora and with two unequal spurs.

Abdomen oval, pointed at tip, longer than the thorax. Ovipositor not or very slightly protruding (Fig. 3).

Length: 3·5-5 mm.

♂ unknown.

Type will be deposited in the collection of the Zoological Survey of India, Calcutta; paratypes at the Jute Agricultural Research Institute, Barrackpore and at the Museum d'Histoire Naturelle, Geneva, Switzerland.

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**The Measurement of Grassland Productivity.** Edited by J. D. Ivins. 1959. Butterworths Scientific Publications, London. Price 35sh.

Though grasslands occupy almost one fifth of the area of the earth, attempts at their development on systematic lines are of recent origin. More so in India, where unfortunately this aspect of Agriculture was sadly neglected for a long time, though the country possesses probably the highest cattle population in the world.

Grassland research techniques can never be standardised for general adaptation because the grasslands differ in their pattern owing to a great variation in edaphic, climatic and biotic factors. This book, therefore, cannot be expected to give general recommendations regarding the techniques. However, the techniques which bring livestock into the final assessment of grasslands have rightly been given particular attention. The book clarifies many confusions regarding the relative merits of the grassland research techniques; and should, therefore, be welcome in India where improvement of the indigenous grasslands has become a "must" in the face of serious malnutrition of the cattle existing at present.

The Measurement of Grassland Productivity is divided into five parts and is a compilation of papers, relating to the grassland productivity, presented in the Sixth Easter School in Agricultural Sciences held at the University of Nottingham School of Agriculture.

In 'Part One: General Aspects' William Davies has given a brief, but appropriate, account of the techniques used in grassland research and stresses the need for searching and critical field observations and bioassays in relation to the whole pasture problem. Emphasis has also been laid on the need for greater precision in the case of experiments involving animals in pasture, because in the ultimate analysis, it is the animal which has to benefit from improved pasture. E. Klapp deals with the grass production available to grazing. He aims to trace the effects of management and manuring on production of herbage, and shows which kind of management comes closest to the actual conditions of alternate grazing. T. E. Williams has shown that the inclusion of white clover in leys improves the yield of succeeding wheat crop. Leys have also been shown to improve the soil conditions.

In 'Part Two: Herbage Growth' R. P. Hawkins advocates the measurement of characters of a number of individual plants of the same variety growing at random in controlled plots. Statistical analysis applied to the data gathered from such studies provides, according to him, the range of variation of characters in that particular variety. His studies on the ear emergence of certain varieties of plants substantiate these views. Ll. I. Jones attempts to show that certain plant characters influence the results obtained during the studies of behaviour and production of different varieties of herbage plants, and that the relative value of different varieties varies for different conditions. He further stresses that, while assessing the relative value of two varieties, care should be taken to maintain the particular conditions under which the study is to be made. It

has also been shown that mowing as a practice cannot substitute grazing and, hence, may not reflect the grazing value of the herbage. He cautions against relying on data collected from small plots and advocates the approximation of conditions during trial to those obtaining during practical farming. J. Warren Wilson points out some errors inherent in the use of point quadrat method and shows that it can be made accurate by inclining the quadrats at certain angles. J. O. Green states that measurement of herbage yield or the rate of herbage production should be considered since it is an indication of the plant vigour, either inherent or as a function of the treatment it receives. He advocates the cutting of herbage very close to or at ground level. To avoid soil contamination, washing or ashing of herbage samples is recommended.

In 'Part Three: Consumption of Herbage by Livestock' C. Line suggests the production of results in terms of salable products, such as meat and milk, in order to convince the farmers of the value of research work in this direction. J. Davison discusses the sampling of herbage with an autoscythe and shearhead. J. Lowe has discussed the lines on which grassland experimentation developed in southern Ireland during post-war period and has traced the pasture yield measurement techniques involved.

In 'Part Four: Animal Production from Grassland' F. E. Alder has described the pasture experiments with animals. W. Holmes has discussed the relationship between grazing intake and animal production. In doing so, he has considered the feed factors, compared the equations of Wallare and Cox *et al.* with the normal British feeding standards and also taken into account the value of current farm management estimates of cow equivalents, and the interaction of feed animals factors. D. S. Maclusky has attempted to show that output measured by animal production data may be increased by management factor. He feels that the stock carrying capacity of an area can, under certain conditions, give fairly accurate results. P. Boeker discusses the 'Falke-Geith' method of pasture evaluation and states that it is not suitable for trials which seek to establish minor yield differences. J. D. Ivins states that under certain conditions of intensive grassland production, yields of dry matter and the digestibility thereof are more reliable measures of herbage values than milk production or live-weight gains which are frequently limited by the animal potential. W. F. Raymonds discusses the nutritive value of the herbage and the various factors associated with this aspect of herbage. R. J. Lancaster has given some information on the Chromium-faeces N. Method of estimating herbage intake by animals. J. Davidson has discussed how the digestibility of herbage can be measured with dairy cows, indoor, with reasonable accuracy.

In Part Five: Farm Scale Measurements. J. Clark discusses the grassland production on dairy farm in England and Wales, by what he calls as direct and indirect measures. Rex Paterson discusses different methods of measurement of grassland production in field as well as on cows.

The book should be of great value to workers connected with agronomy and pastureland ecology. It is accompanied by neatly presented tables and figures and extensive bibliography.—J. V. S. & P. K.

**The Third All-India Conference of Sugarcane Research and Development Workers**—1959. Indian Central Sugarcane Committee. pp. i-vi, 1-421, Price Rs. 22.

The Proceedings of the 3rd Biennial Conference of Sugarcane Research and Development Workers held at Pusa (Bihar) in October 1957 has just been released by the Indian Central Sugarcane Committee. The Proceedings are broadly divided into two parts; the first dealing with the usual formalities of addresses, etc., and the second is devoted to proceedings of the sectional meetings which cover all aspects of sugarcane research and development in India.

The section on breeding and botany includes papers on wild *Saccharum*, anatomy of rhizome, chromosome numbers, breeding behaviour, and chimaera. Studies and a review of and flowering in sugarcane (a paper on study on lodging agronomy should have been in proper place for it) is also included under this section. Papers presented in the agronomy and physiology section cover a very large field, from effect of manures on sugarcane production to the control of weeds, hampering sugarcane in the field and certain aspects of physiology of the plants.

The papers presented under Chemistry and Soil Survey section mostly deal with the chemical aspects of the soil. Chemistry of the sugarcane price should have also found a place here. The section on entomology presents a record of experiments conducted to control the pests that greatly damage sugarcane crop in India. Emphasis has been laid on the control of various pests under Indian conditions.

The penultimate section is devoted to mycology. The various papers presented reveal that the Indian Mycologist has clearly grasped the range and control of diseases that pester this crop. The concluding chapter presents a broad outline of the development of the sugarcane industry during the First Five-Year Plan and recommendations towards better popularization of the research results. This section also includes an interesting paper on the control of rats in the sugarcane fields.

Each paper records useful data and is documented with facts and figures and the relevant literature.

Much care does not seem to have been given to editing and this is evident right from the matter printed on the cover. The volume should have been titled "Proceedings of the 3rd All-India Conference of Sugarcane Research and Development Workers". It should have started with the introduction or a preface which could conveniently include the progress, the office bearers and the acknowledgements. Sectional Meetings, a chapter heading, has been repeated with each section; so is the word sugarcane in section headings. However, barring a few other errors the book has been well produced. Except for binding, the press, (identity not disclosed) has done a good job.

The Central Sugarcane Committee deserves compliments for having published this volume and placed in our hands a well documented memoir on sugarcane research and development. The book is bound to prove useful to those interested in this important industry.—P. K.

**Sugarcane Research in India** (1929-1954) Indian Central Sugarcane Committee, New Delhi. pp. 1-82, Price Rs. 5·00.

This publication gives a resume of the research done on agronomy, physiology, botany, breeding, soil chemistry, entomology, mycology and statistics of sugarcane in India during 1929-1954 and suggestions for future work on each aspects. It will prove of immense help to research workers.—P. K.

**Indian Tobacco**—1960; The Indian Central Tobacco Committee, Madras. pp. xxii+413.

Tobacco is one of our important export commodities and India earns about Rs. 160 million in foreign exchange through its export each year; about Rs. 80,000 are realized by way of agricultural cess levied on the exports. Whereas the origin and history of tobacco is still a controversial subject, it is more or less a fact that this crop was introduced into India by the Portuguese in the beginning of 17th century A.D. However, organised efforts in the field of tobacco research were only initiated in the first decade of the 20th century at Pusa (Bihar) and a number of strains have been released from this Station since then. It is gratifying to note that at present tobacco forms one of our important subjects of research and the Indian Central Tobacco Committee has been generally responsible for research advancements made in this commodity. Therefore, it is appropriate and timely that this Committee should have released for sale a comprehensive monograph on Indian tobacco.

The *Indian Tobacco* provides rather a complete digest of the developments in research of the various types of this commodity and its marketing in India and, wherever possible, in the world. The results of research discussed have taken into consideration the field conditions existing in India and, therefore, the book should prove of great value in furthering research for improvement of the tobacco crop for production of still finer varieties.

The monograph is divided into three parts. Part one gives a general account of the origin of tobacco and its different varieties with reference to their current use, and the economic importance of the crop. In Chapter 2, charcteristics of the soil on which the different types of the commercial varieties grow, are discussed in detail with reference to the yield produced by each under different cultural and climatic conditions. Effects of climate and seasonal variations in the growth of tobacco leaves are also discussed. Taxonomy of the genus *Nicotiana*, with particular reference to species grown in India, is dealt with in Chapter 3 which includes an account of the origin and relationships of the various sections and sub-genera of the genus, and an enumeration of chromosome numbers of the various (60) species. Morphology, anatomy sporogenesis and embryology are discussed next (Chapter 4). Variability, botanical classification and commercial types of tobacco are lucidly described. Cytology and cytogenetics (Chapter 5) record all known information on the subject. Genetics and Plant Breeding, which should have formed a part of Chapter 5 discusses (Chapter 6) direct bearing of these subjects on commercial utilization of the various species and hybrids, and future prospects of the seed in improving the quality of tobacco. Physiology of the crop (Chapter 7) has been studied with reference to the seed and its germination, the nutritive requirements of the crop, effect of hormones on vegetative propagation and control of suckers. The next chapter is appropriately devoted to

agronomy and is one of the very well written chapters of the book. The organic constituents of the tobacco plants are discussed in the chapter on chemistry (Chapter 9). The various diseases (Chapter 10) and pests (Chapter 11) have been separately dealt with. In each case, the modern control methods are described. These should prove of great help and utility to tobacco growers in the country and, as a matter of fact, should be translated into the regional languages and distributed among the extension workers. The various curing methods of tobacco prevalent in India are also described and illustrated (Chapter 12). Seed multiplication (Chapter 13) should have followed agronomy. It gives detailed information on biotypes, contamination, off-types, collection of seeds, their processing and treatment.

Part two is devoted to the commercial types of tobacco. Detailed information is provided on distribution, growth season, soil types, varieties under cultivation, agronomic practices, the disease and insects, etc., grading, yield and marketing of each type.

Part three is devoted to marketing and provides information on systems of assemblage, grading into various commercial varieties, etc.

Each chapter is documented with up-to-date data, illustrations and the pertinent literature referred to in the text. A comprehensive subject index is also provided. Careful editing (c.f., use of capital T and R in specific names *tabacum* and *rustica*, respectively is most unfortunate; lack of table numbers; the system used in numbering figures is incompletely followed, usually continuous figure numbers are also maintained in this system), and care towards production aspects (c.f., binding, lack of title on cover and spine, the careless use of antique types in contents, reproduction of half-tones, etc.) would have greatly enhanced the value of this otherwise highly authentic tome.

The *Indian Tobacco* will be of great use to research workers, specialists and the tobacco industry.—P. K.

## Instructions to Authors

*Indian Journal of Agricultural Science* is a quarterly journal. Articles of agricultural interest, based on original research, are accepted for publication. The manuscript, including legends for illustrations, graphs, etc., should be neatly typed (double space on uniformly sized paper) and sent in duplicate to the Editor (Research), Indian Council of Agricultural Research, Krishi Bhawan, New Delhi. The articles must be concise (not more than 20 typed pages). Adventitious material, relevant to doctorate thesis, should be excluded. A two-inch margin should be allowed on the left hand side of each page for editorial use. Normally, only one paper by one author will appear in a single number.

The articles sent for publication should be exclusive for this journal, and if the paper has appeared in an abbreviated form elsewhere (e.g. *Sci. & Cult.*, *Current Sci.* or *Nature*) this must be stated. Each article should have a brief summary of not more than 360 words. The hierarchy of headings being followed in the journal should be adhered to. Do not underline the headings. If the headings are intended to be serialized, use Arabic numerals or ordinary English alphabetical letters. Avoid footnotes, use of unusual symbols and elaborate tables (*they are expensive*).

In the case of botanical and zoological names, the International Rules of Botanical/Zoological Nomenclature should be strictly followed. Genetic and specific names must be underlined. In the case of a plant/animal which is not widely known, the name of the family should be given in brackets. The titles of journals should be abbreviated in accordance with the *World List of Scientific Periodicals*. The titles of books should not be abbreviated.

The references to literature, arranged alphabetically according to authors' names, should be placed at the end of the article, the various references to each author being arranged chronologically. Each reference should contain the name of the author (with initials), the year of publication, the subject title, the abbreviated title of the publication, the volume and page numbers. A sample citation is as follows: JODON, N. E. 1957. Inheritance of some of the more striking characters in rice. *J. Hered.* **48**(4): 181-92.

In the text, the reference should be indicated by the author's name, followed by the year of publication enclosed in brackets, e.g., (Moore, 1951). When the author's name occurs in the text, the year of publication alone need be given in brackets, e.g., Moore (1929). Avoid cross references by page numbers.

The illustrations should be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. The photographs should be on glossy paper, at least of postcard size, and should be sent properly packed so as to avoid mutilation in transit.

Every paper is scrutinized by a referee. The author is subsequently asked to revise the paper in accordance with the referee's (or editor's) comments.

The proofs are sent to authors for correction, and these should be returned *within seven days of their receipt*. In the proofs, only errors of typography or of fact are permitted to be corrected, as the proofs are not the place for alteration of style. Therefore, corrections likely to lead to an additional payment to the press will not normally be accepted.

In papers of joint authorship, the extent of responsibility of the different authors must be indicated and one of them must accept the responsibility of proof correction and other correspondence incidental to the publication of the paper.

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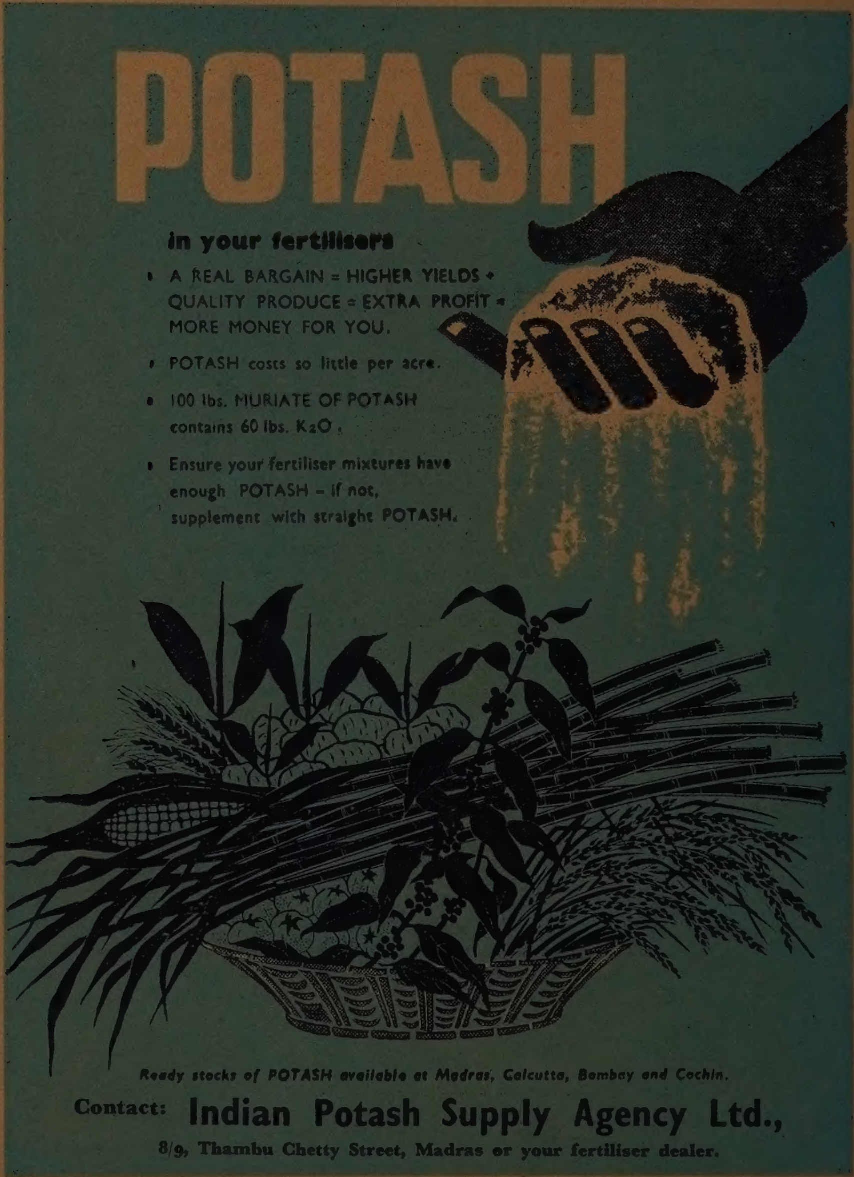


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